DESIGN CONSIDERATIONS OF CERAMICS IN ARCHITECTURE

A THESIS
SUBMITTED TO THE DEPARTMENT OF
INTERIOR ARCHITECTURE AND ENVIRONMENTAL DESIGN
AND THE INSTITUTE OF FINE ARTS
OF BILKENT UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF FINE ARTS

By
Müfer Gönenç
May, 1998

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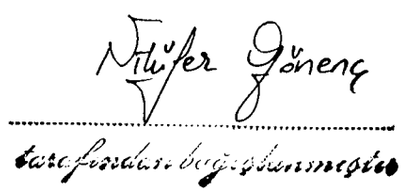

By

Nilüfer Gönenç

May, 1998

I certify that I have read this thesis and that in my opinion, it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts.

Asist. Prof. Halime Demirkan (Principal Advisor)

I certify that I have read this thesis and that in my opinion, it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts.

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I certify that I have read this thesis and that in my opinion, it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts.

Prof. Hamiye Çolakoğlu

Approved by the Institute of Fine Arts

Prof. Dr. Bülent Özgüç, Director of the Institute of Fine Arts

ABSTRACT

DESIGN CONSIDERATIONS OF CERAMICS IN ARCHITECTURE

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M.F.A in Interior Architecture and Environmental Design
Supervisor: Assist. Prof. Dr. Halime Demirkan
May, 1998

The aim of this thesis is to explain the importance of ceramics in architectural design. The considerations for ceramic tiles that must be kept in mind while making a design are mentioned. One of them is the mechanical and physical characteristics, which have great importance in selecting ceramic tiles. Also another consideration, the installation methods are defined, which have a great role in completing the design. Later, the place of ceramics in architectural decoration is discussed, both in interiors and exteriors. The design elements, that form up the main characteristic of design, the design possibilities they have created, and their effects on the environment are mentioned, by giving examples from the projects of some architects, interior designers, and ceramists. The areas of use of ceramic tiles, both residential and public areas, are also examined. Concerning the functions of these areas, and the difficulties in selecting ceramic tiles for the right application, a design guide is prepared.

Keywords: Ceramic Tile, Architectural Decoration, Design Elements, Residential Areas, Public Areas.

ÖZET

MİMARİDE SERAMİĞİN TASARIM ESASLARI

Nilüfer Gönenç
İç Mimarlık ve Çevre Tasarımı Bölümü
Danışman: Yrd. Doç. Dr. Halime Demirkan
Mayıs, 1998

Bu tezin amacı, mimari tasarımda seramiğin önemini açıklamaktır. Bir tasarım yaparken kaplama malzemesi olarak seramikle ilgili esaslar vurgulanmıştır. Bu esaslardan biri, seramik malzemenin seçiminde çok büyük önemi olan mekanik ve fiziksel özellikleridir. Tasarımın tamamlanmasında büyük rolü bulunan diğer bir esas olan, döşeme metodları anlatılmıştır. Daha sonra seramiğin hem iç, hem de dış olmak üzere, mimari dekorasyondaki yeri açıklanmıştır. Tasarımın ana karakterini oluşturan tasarım elemanları, bunların yarattığı tasarım olanakları ve çevre üzerindeki etkileri, bazı mimar, iç mimar, ve seramik sanatçılarının çalışmalarından örneklerle anlatılmıştır. Seramik malzemenin kullanım alanları, hem konut, hem de kamu alanları olmak üzere, incelenmiştir. Bu alanların fonksiyonları ve doğru uygulamalar için seramik malzemenin seçiminin zorlukları göz önünde bulundurularak, bir tasarım kılavuzu hazırlanmıştır.

Anahtar Kelimeler: Seramik Karo, Mimari Dekorasyon, Tasarım Elemanları, Konut Alanları, Kamu Alanları.

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First of all, I would like to thank Asist. Prof. Dr. Halime Demirkan, for her help, support and tutorship, in completing this thesis. Secondly, I would like to thank Prof. Hamiye Çolakoğlu, who brought me up to these days, that I would not be able to write this thesis without the education she had given to me. Last, but not least, I would like to thank all of my friends, especially Funda İğdir, and my dearest parents, whom I owe a large part of this thesis, for the great support they have given to me.

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1. INTRODUCTION

The occasional ornamental use of paving, to whole walls, ceilings, and other surfaces has been a continuing adventure for ages. From the magnificent applications in churches and palaces, the use of tile spread to household use, beginning with baths and kitchens. Because of its long-lasting values, capabilities, and its continuing development into expressions, tile is catching the imagination of design professionals for uses far beyond the "wet" areas of the home today. A developing demand for greater decorative appeal has kept the interest for the finest in design, by the tiles' stylistic advances worldwide. Ceramic tiles have long been known to add permanent value to any property, and now they are seen as more attractive participants in the aesthetic of the project. Function, however, has not lost its importance, even though tiles are now available in a staggering of design choices. Because different types of tiles have various capabilities, selection of the appropriate tile for each application is important. It is hard to imagine any material that could involve a broader range of design, and functional choices than ceramic tiles.

With these concerns in mind, the aim of this thesis is to explain the importance of ceramics in design process, that although design possibilities of ceramic tiles are endless, knowing how to select a material is so important for architects and interior designers for creating aesthetically pleasing and long-lasting installations.

In the second chapter, after a brief description of ceramic tiles, the characteristics of tiles are mentioned, which make them that much important in design and decoration. The second part of this chapter explains the reasons and important points, that ceramic tiles are chosen by architects or designers in their projects. Also another critic factor, in establishing perfect results, is taking care of installation methods, which are discussed in the third part.

The third chapter explains the use of ceramics in architectural decoration, both in interiors and exteriors. In the last part of this chapter, architectural ceramics are discussed, which have a great role in the decoration of the environment.

In the fourth chapter, the design phase is mentioned, including the design elements that form up the character of design. The design possibilities, that can be created by using ceramic tiles, and their effects on the environment are discussed. Later, some comments of architects, designers, and ceramists are mentioned, about the importance and relation of ceramics in architecture, by supporting these with examples from their works or projects.

In the fifth chapter, a guide for architects and interior designers in choosing ceramic tiles is arranged. In this study, some checklists are prepared to be useful in choosing ceramic tiles for the right applications, because selecting the product simply because of its design advantages without considering its properties and performance, can leave a specifier exposed to a variety of possible installation failures.

2. CERAMIC TILES

Since ancient times, man has developed his aesthetic taste, focusing his attention on shapes, colors, combinations, contrasts, general views and spatial and architectonic organisations. Human perceptions are linked to the related stimulation deriving from the environment, but also to subjective variables of a psychological order. This process provides the basis for an enrichment of the creative abilities and imagination of architects, design engineers and interior designers, who try to satisfy the users' aesthetic requirements through modern techniques (Benvenuti, 1993).

> Ceramic tile speaks to the human experience through the international language of design. The deliberately lyrical discourse between solids and patterns, performance and style addresses the complexities of man in his ancient endeavour to master his universe. The appeal of ceramics is universal, answering the primordial call of earth and fire. Through the man's imagination, mere clay is transformed into a dance of colour, texture and light. Architectural ceramics are man's link with the past, his gift to the future. The art of ceramics crosses all cultural barriers, spanning oceans and time to produce innovative designs. Each nation's tile has a distinct personality, its own individual character. Rarely does a contemporary work have such a close relationship with the essence of it culture and its age ("The Visual Dialogue", 1989:177).

Tiles have been a part of architecture ever since the first buildings of brick and stones were erected, so they are an important part of our visual heritage. From this point of view, Van Lemmen says that "The different techniques by which tiles have been made, the great variety of uses to which they have been put, and wealth of

ways in which they have been decorated make up a fascinating and intriguing history" (1993:11).

Glazed wall tiles were first used in 2000 BC for the great building projects in Egypt. The first real evidence of ceramic tiles is found in Ishtar Gate and ceremonial road built in Babylon about 580 BC (Toepfer, June 1996). With the rise of Islam, ceramic tiles gained importance as a material for both interior and exterior decoration. Tile making was the most significant element of Seljuk and Ottoman art and architecture. For almost a millennium, mosques, palaces, medresses, Turkish baths, libraries and public buildings were covered with glazed tiles having lively decorations. The ceramic surfaces on the domes and capped minarets, often in green or blue tones, which meant that the mosques were landmarks that could be seen for miles. The Moors brought the tile art to Spain, and then it spread throughout Europe. Here, tiles were used in the interiors of palaces and the homes of wealthy people, while they were used on the facades of the buildings in Italy and Spain. Mc Ilvain states that, at the beginning of this century, by the modern technology, the artistic tradition of tile is recognised with the increasing variety of tile types and styles (1992). These types of ceramic tiles include ceramic mosaic tile, glazed both wall and floor tile, unglazed floor tile, and quarry tile. According to Wilkers, the current method of classification is a combination of end use, form, and physical properties (1989).

Sunset Bathroom Remodelling Handbook describes ceramic mosaic tile as one of the most colourful and versatile materials in the tile family, which are generally small, 2 by 2 inches or less. They can be found in sheets, mounted on thread

mesh or paper backing or joined with silicone rubber; and can be installed on curved surfaces, such as moulded basins and arches (1983). Areas covered with ceramic mosaic tile may be in all one color, in a random combination of colors, or in geometric or pictorial patterns providing the architect and designer with an almost unlimited variety of effects (Kicklighter and Kicklighter, 1986).

Glazed tile is available for floors and walls, both in residential and commercial areas, with advantage of various patterns and colors, impervious durable finish, abrasion resistance, low maintenance, low water absorption, stain resistance, and slip resistance ("Guide to Ceramic Tiles", guide1, 1998). Glazed wall tiles usually have one coat of glazing, while glazed floor tiles have two or three coats in order to be durable against heavy wear and tear of floor traffic (Kicklighter and Kicklighter, 1986). "Five years ago, the hardest glaze was about as hard as steel, which meant it could be scratched. Now, tiles are available as hard as silica. You can't scratch them" says Mc Ilvain (1992:43).

Unglazed tile is a hard and dense material, taking its color and texture from the materials which the body is made (Tran and Sigman, 1997). Because of their physical properties, they are durable to most of the defects that they receive underfoot. As unglazed are more slip-resistant than glazed tiles, they are often used for installation near outdoor areas, where wetness can be tracked inside (Busch, 1988b). These tiles are also suitable for heavy traffic areas like building lobbies and shopping malls, both indoors and out. Unglazed tiles include two main types, which are Terracotta or Clinker, and Impervious Stoneware, also known as Porcelain Tile ("Ceramic Tiles", 1997). Terracotta's rate of absorption may be more

than other unglazed tiles, but they have the most natural and warm colors that will enhance residential and light commercial floors. It is easy to handle, fireproof, waterproof and can be quickly set and cleaned easily (Mc Ilvain, 1992). Porcelain tile is the strongest and most abrasion resistant, chemical and acid resistant ceramic tiles. It has the lowest abrasion rate, very low water absorption characteristic and stain resistance, high tensile strength, ease of maintenance, and slip resistance ("Ceramic Tiles", 1997). *American National Standards for Ceramic Tile* defines porcelain tiles as being dense, smooth, and impervious, with water absorption of 0.5% or less (cited in Mc Ilvain, 1992). The natural colors of porcelain are permanent and will not change with time and wear because the pattern is the same throughout the tile ("Ceramic Tiles", 1997).

Perhaps the first generation of ceramics is quarry tiles, that helped to go beyond the limits of mere decoration ("Quarry Tiles", 1989). Quarry tiles are dense and durable, that's why they are the favourite flooring materials, when strength and slip resistant are key components of design ("Floor Show", 1989). They have a high breaking strength to handle heavy traffic, and chemical resistance to be used for patios or roof decks, food manufacturing, preparation and serving areas ("Quarry Tiles", 1989). They are usually deep red in colour, but also buff, grey and green tones are common (Wilkers, 1989).

Today, because of the quality, variety, natural beauty, design possibilities and functional practicality, it has become nearly impossible to find an interior or exterior setting where ceramic tiles cannot be applied.

2.1. Characteristics of Ceramic Tiles

If it is asked to people about what makes ceramic tiles so special, there will be a variety of responses. According to some tile experts, the most important factors are the color and design of their product, while others talk about its practical application in different situations. But, the important point is that, both are true. Tile is, without any doubt, an attractive and a functional surface covering. According to Corbella, structural limitations of the materials can influence the choice in different ways, depending on the various physical and mechanical characteristics (1989).

The Gail Company of Architecture and Ceramics specified some requirements for ceramic tiles for floor and wall claddings. They can be classified according to the following criteria:

- Mechanical Loadbearing Capacity
- Resistance to Chemicals
- Insensivity to Thermal Shocks, Temperature Variations and Fire
- Cleanliness and Hygiene
- Durability and Service Life
- Slip Resistance
- Abrasion Resistance
- Electrical Conductivity
- Color Permanence
- Cost ("Ceramics for Industrial Applications", 1990).

All types of tiles share the qualities of durability, fire resistance, color permanence and easy maintenance. Other characteristics change in tiles to different degrees. It is important to know these characteristics in order to make a proper tile selection ("Guide to Ceramic Tiles", guide8, 1998).

2.1.1. Mechanical Loadbearing Capacity

The mechanical strength of a tile is measured by its breaking strength and hardness. It is a consideration especially for floor tiles, but not so necessary for wall tiles (Zelinsky, 1995). Ceramic materials have extremely high comprehensive strengths ("About Ceramic Tile", 1997). "Ceramic tiles generally demonstrate a breaking strength greater than the practical requirements for most floor applications (generally 40 kg. for wall tiles, and 113 kg. for floor tiles)" ("Ceramic Tiles", 1997).

The most severe mechanical load strains, such as abrasion, bending load, impact shock and rolling load, are naturally found on floors which are often required to offer special safety at the same time. For floor tiles, the high stresses imposed by vehicles depend on the weight of the vehicle, the hardness and width of the wheels and rollers and on the driving speed. As steel wheels involve exceptional loads, they should essentially be avoided. The grain size of the ceramic material, the high firing temperature and the special hardness of the vitrified material mean that, tiles have a hardly noticeable depth-abrasion wear, which is far below the standard values. The most extreme hydromechanical loads occur in liquid

containers, drainage channels, on floors subject to constant wet load and in cleaning operations ("Ceramics for Industrial Applications", 1990).

2.1.2. Resistance to Chemicals

The materials used for the sub-structure, such as concrete, plaster, masonry, are usually not chemical resistant. The main function of ceramic claddings and finishes is to protect these building components from chemical attack. This means that they themselves must be chemically resistant. Cement bonded laying and pointing mortars should, if necessary, also be replaced by acid-resisting materials ("Ceramics for Industrial Applications", 1990).

A test of atmospheric chemicals on natural materials, like ceramics, has recently been added to the laboratory tests. By that way, the prevention of corrosion caused by atmospheric chemicals has become a concern. Corbella states that, the most corrosive atmospheric agents are sulphur dioxide and carbon dioxide. Both are related to population density, industry, and traffic, especially in large urban areas. These compounds become acids when they react with elements in the atmosphere, and they can cause corrosion. Generally the corrosion progresses beyond the surface cladding; but as time passes, these acids will damage the loadbearing structures as well (1989).

Many ceramic tiles resist chemical erosion. Most of the unglazed, impervious tiles have excellent resistance, while some glazed and decorated tiles resist most household solutions. But, unfortunately some types of acids may affect certain

glazes and design (Zelinsky, 1995). Ordinary staining, household cleaners, acid and alkalis are the most common chemical attacks. Unglazed tiles have more resistance to chemicals than glazed tiles, unless special glazes or designs are used ("Guide to Ceramic Tiles", guide8, 1998).

2.1.3. Insensivity to Thermal Shocks, Temperature Variations and Fire

Thermal shock is a condition of stress brought about, by a large temperature difference across a body or a glaze ("Ceramics for Industrial Applications", 1990). Stresses imposed on floor and wall claddings by thermal shocks and temperature variations are found in cleaning processes, industrial operations using hot liquids, and installations both indoors and out in different climatic conditions. Zelinsky explains that, the size of each ceramic tiles may change due to various weather conditions. This means that the bonding mortar needs elasticity property to compensate for this change. Water absorption is a factor in outdoor applications where water can penetrate into the tile body, and cause it to crack during cycles of freezing and thawing. Unglazed tile with a high absorption rate, such as terra-cotta may need sealing, if it is going to be used for outdoor (1995).

Ceramic tiles also have a good insulation property, with a capacity both to remain cool in hot climates, and to retain heat in colder ones. In homes, which are designed to be energy efficient, ceramic tiles can absorb and retain the sun's heat, often acting as passive solar collectors. This is because of ceramic tiles' thermal conductivity coefficient. This thermal conductivity coefficient is 0.35-0.65 Btu/h ft

degrees F, or in metric 0.5-0.9 Kcal/m.h degrees C ("Guide to Ceramic Tiles", guide8, 1998).

By the decision of many companies, ceramic tiles are accepted to have the highest grade in the comparisons of building materials under fire. As it is completely fire-proof at any temperature, it is a noncombustible material, that it will not feed a fire and its surface will not give off any toxic gases or fumes during a fire. It can also provide protection for structural surfaces if a fire should occur ("Ceramic Tiles", 1997). Because of these characteristics of ceramic tiles, they can work well around open flames, hot objects, or any other area under extremely high temperatures. When it is used on a countertop, it will not burn or melt; if a hot substance is put on its surface. Ceramic tiles will not be damaged by the wood sparks, when it is used as the surround of a fireplace or wood stove hearth. It is found that in the late 70's, the Ceramic Tile Institute of California demonstrated a T.V show about the combustion and toxic smoke of a burning plastic tub and shower surround. People are so attracted by these pictures, and because of this, there has been a high rise in California's use of ceramic tile showers and tub surrounds ("Lifestyle is Tile" ch.02, 1997).

2.1.4. Cleanliness and Hygiene

Tiling provides a surface that is hygienic, easy to clean and waterproof. Ceramic tiles will not retain liquids or absorb fumes, odours or smoke, making them suitable for any environment where hygiene is essential. It is probably the most hygienic surfacing material, that it does not show dirt and produce microbes, because of its

non-porous structure, low water absorption, and glazed surface. Also Monari adds that, unlike rugs, tile does not release gases such as those emitted by some carpets containing nylon or acrylic fibbers (1996).

Glazed ceramic tiles do not retain dust or stains because, they can not stick well to the surface of the tile. Ordinary household cleaners, acids and alkalis can be used for maintenance. Glazed ceramic tiles have good stain resistance, but spills of any type should always be wiped up immediately. Its' hard, nonporous surface is a naturally low maintenance finish. Because of its' composition, it doesn't absorb dust, germs, pollen and other living space pollutants. Living with ceramic tiles is like a breath of fresh air for the ones suffering from allergy ("Ceramic Tile", 1997).

Most tile products require minimum maintenance. Glazed and unglazed tile can be easily cleaned with clear water or mild non-soapy household detergent beforehand. It will be better to wipe dry before that clear water rinse. It is necessary to clean ceramic tiles from soil, grease, residue, soap, sealers, dampness and water, to prevent slippery conditions ("RBC Tile&Stone Installation Guide-Maintenance", 1998).

Freeman explains the water absorption property of ceramic tile by satating that, the water absorption of the hard surface flooring material gives the designer information related to two different characteristics of the flooring material. The first is the relative density of the material, as denser materials will absorb less water. They are also stronger and perform well in higher traffic applications. The water absorption reading also gives the designer an idea of how well the product will

resist or will absorb waterborne stains. A product with a very high water absorption will absorb water-based stains more easily. These products often absorb other types of stains, such as grease-based stains, dust and dirt more easily (1997). Table 2.1 shows the water absorption rates of different types of ceramic tiles.

Table 2.1. Water Absorption Rates Of Some Ceramic Tile Types ("Guide to Ceramic Tiles", guide10, 1998).

Surface Finish	Type of Tile	Water Absorbtions (%)
Glazed	Clinker	0-7
	Cottoforte	4-15
	Earthenware-White body	6-25
	Majolica	15-25
	Red body-Single fired	0-12
	White body-Single fired	0-3
Unglazed	Clinker	0-7
	Impervious stoneware (Porcelain tile)	0-1
	Red stoneware	0-4
	Terracotta	3-15

It is seen from the table that, Cottoforte, Earthenware-Whitebody, Terracotta, and especially Majolica absorb stains more than the others. On the other hand, Impervious stoneware or porcelain is the most stain-proof type of ceramics.

When all these things are considered, it is easy to understand why ceramic tiles are the best choice for hospitals, food processing areas, water purification areas, restaurants, laboratories, swimming pools, bathrooms, public restrooms, and any other space which requires high levels of hygiene.

2.1.5. Durability and Service Life

As time passes, all glazed tiles are subject to wear and tear, depending on specific conditions. To determine which glaze is suitable for specific applications, each one has been tested and classified on the MOHS Scale according to hardness and recommended use:

"**Application Guide**

Group 1 (MOHS 4-5): All interior and exterior vertical surfaces and bathroom floors.

Group 2 (MOHS 5-6): General residential except entry and kitchen floors.

Group 3 (MOHS 6-7): All residential, light commercial floors with diffused traffic.

Group 4 (MOHS 7-8): Moderate commercial floor use.

Group 5 (MOHS 8-9): Commercial applications where extra durability is required" ("McIntyre Tile Company INC."; 1998).

A ceramic tile's durability lasts forever. As long as the installation was properly done, and the color or design was not boring anymore, there is no reason why a tiled surface should not last for hundreds of years. That's why, it is important to bear this in mind when selecting tile. The colors and designs must still be appropriate when it is time to replace the furnishings.

As Toepfer has written; ceramic tiles in the Embarcadero Center, in San Francisco, is a good example for its characteristic of durability. In this center, after 30 years, the tiled surfaces are still impeccable (Figure B.1). When the enormous daily wear

and tear of these surfaces are considered, this statement sounds to be unbelievable, but however, it is true:

> Taking into account the number of people working in the three 40-story-high towers and in the retail areas around the bottom floors, and calculating the in-and-out movements per person on a very cautious and moderate basis, we come to about 15,000 "movements" per day. Multiply this figure by 22 working days per month and you arrive at an annual number of movements of about 4 million. What this means is that in 30 years, 118,000,000 movements took place. To this figure, we have to add the tourists passing through and the people from neighbouring office building that use the sidewalks regularly. This pedestrian traffic, over a period of three decades, amounts to another 10 million movements. Therefore, we can say that, figuratively speaking, about half of the population of the United States walked once over the Embarcadero Center's tiled surfaces; and they still look beautiful (1996:28).

The long term resistance of the Embarcadero Center's tiled surfaces to abrasion and staining, the ease of maintenance over all these years inspite of an incredible load of daily wear and tear, their exposure to torrents of rain and glaring sun, and after all these effects, remaining virtually unaffected, represents that ceramics is the most durable building material of mankind (Toepfer, 1996).

2.1.6. Slip Resistance

Slip resistant ceramic tiles are available for use in kitchens, bathrooms, and other areas subject to frequent grease and water spills. The coefficient of friction (slip-resistance) has always been an important consideration in selecting ceramic tiles for use on floors and walking surfaces. According to the requirements of the Americans with Disabilities Act (ADA), certain walking surfaces must have higher

slip-resistant characteristics than normal. Ceramic tile manufacturers prepare test results, detailing the coefficient of friction of their products, so that designers and owners can make the right selections of ceramic tiles for use on walking surfaces.

Freeman explains the static coefficient of friction testing, which gives the design professional an idea of whether a particular flooring material will meet the industry standards for slip-resistance. According to this test, the higher the number, the more slip-resistant the material is. Freeman explains the ceramic tile industry standards for slip-resistant flooring as; static coefficient of friction of 0,5 or higher for residential applications, and a static coefficient of friction of 0,6 or higher for commercial applications (1997). There has been much argument over testing the slip resistance of surfaces. Kohr states that, American Society for Testing and Materials (ASTM) methods do measure "relative" slip resistance of various surfaces, although as pointed out by numerous researchers, a true measurement of the coefficient of friction is very difficult to make (1990). According to him, people can walk on floors with static coefficients as low as 0,28 to 0,30 without falling. A walking or bathing surface shall be designed, selected, and installed that is capable of providing adequate slip resistance under anticipated environmental conditions (maintenance, cleanability, weather, humidity), contamination (water, oil, grease), and pedestrian load factors (volume, public or worker, footwear, demographics) (1990).

According to Freeman, design professionals may want to select a higher static coefficient of friction rating for exterior applications, for wet areas, or for areas such as food service applications where the floor may be greasy, dirty or

contaminated (1997). Further, the interpretative guidance to the ADA recommends a static coefficient of friction of 0,8 or higher for ramp areas. During the material selection process, the designer should consider laboratory test results of the static coefficient of friction tests. This allows the designer to compare the relative slip-resistance performance of materials before selecting and specifying a particular product.

2.1.7. Abrasion Resistance

The abrasion resistance of a hard surface flooring material gives the designer an idea of how well the surface of the material will withstand foot traffic or other types of abrasion related wear and tear. According to Freeman, this is particularly important for glazed tiles or for materials with a special surface finish, such as polished stone. If the designer is designing a high traffic area, the abrasion resistance rating can be used to compare the relative performance of several products and determine which of those products will withstand the heavy traffic of the installation (1997).

Abrasion resistance is an important consideration when selecting the proper floor tile for a project. Some tile surfaces or glazes will not scratch or scuff even under the heaviest industrial traffic. Others are only suitable for light residential traffic, like bathrooms. A tile's abrasion resistance will determine where the tile is best applied. European firms commonly assign their glazed tiles a number from 1 to 4 to indicate their abrasion resistance and recommended usages as seen in Table 2.2. Monari observed that, this classification is done according to results of the

Porcelain Enamel Institute (PEI) abrasion test. According to this classification, "Classes 1 and 2 are recommended for wall applications; class 3 for light to moderate residential traffic; class 4 for moderate to heavy residential and light commercial traffic; and class 4+ for heavy to extra heavy commercial applications" (1996:20).

Table 2.2. Standards For Determining The Proper Tile For A Home Improvement Project (Laboratory tests to measure the abrasion resistance are made according to the PEI method) ("Ceramic Tile", 1997).

PEI 1	Light Residential Traffic	Tiles suited to areas of the home, such as baths or bedrooms, where soft footwear is worn.
PEI-2	Moderate Residential Traffic	Tiles for general residential areas, except kitchens and entrance halls or other areas subject to direct outdoor traffic.
PEI-3	Residential Traffic	Tiles suited to maximum residential traffic in all areas.
PEI-4	Commercial Traffic	Tiles suited to public areas where moderate to heavy traffic occurs (hotel lobbies, restaurants, supermarkets and banks)

In the same sense, Siegel classifies abrasion resistance of ceramic tiles according to the amount of stress:

> Very light stress: Suitable for light use; kitchen, bath and wine cellar walls.
> Light stress: Suitable for residential bedroom and powder room floors, or light traffic areas no subject to abrasive eroding materials.
> Moderate stress: Floor tiles suitable for light traffic, residential use such as bathrooms, or areas subject to minimal abrasive eroding materials. Many of the tiles in this category may also be used on residential kitchen and dining room floors. However, bear in mind that they are not totally wear or impact resistant. These tiles can also be used as a decorative inset with floor tile suited to heavy stress.

Normal stress: Suitable for residential kitchen and hallway floors; also light traffic commercial floors such as reception areas, offices and boutiques, or any areas subject to normal foot traffic and abrasive materials.
Heavy stress: Suitable for commercial floors, patios, terraces, and balconies with minimal exposure to moisture (1989:136).

2.1.8. Electrical Conductivity

Electrical applications differ so much, that ceramics offer a variety of electrical characteristics. Ceramic tiles are electrically insulating. It does not accumulate electrostatic charges, because of that a ceramic floor will not produce electrostatic shocks. Zelinsky explains that, ceramic tiles with conductivity characteristic, are made from special body materials for use in hospital operating rooms or computer rooms, where delicate electronic instruments can be found (1995). These areas are places where electrostatic charges can threaten personal safety. Special electroconductive, antistatic ceramic tiles are produced for these areas, which require special installation techniques to ground ("Guide to Ceramic Tiles", guide8, 1998).

2.1.9. Color Permanence

Ceramic tiles do not fade like carpeting or wood flooring after years of exposure to sunlight. Unlike many wall and floor coverings, the coloring materials in ceramic tiles will not be affected, either by changing or fading. The reason is that, as color is fired into a tile's clay body in unglazed tiles, or onto a tile's glazed surface, fading cannot occur.

Treister observed that, at high temperatures, there may become some defects on the color of many materials like linoleum and rubber, or they may begin structurally to break up, that's why they are not suitable for heated floor systems. On the other hand the color of ceramic tiles is unaffected by increased temperatures, so it is also ideal for floor warming system applications (1998).

2.1.10. Cost

Sometimes, in any building project, economic factors largely displace all others, for instance a liking for a particular material. Economic considerations can only be left aside, if the choice of materials involves only aesthetic considerations and other aspects of the project are neglected.

The initial cost of ceramic tiles may be higher than most alternative products, but it is less expensive in the long run because it doesn't require replacement every few years. Consumers often refer to ceramic tiles as an investment, and the Real Estate Appraisal Guide lists tile as a permanent product that increases resale value. But most importantly, homeowners seek beauty, performance and value which only ceramic tiles can deliver (cited in "Attractive Advantages", 1997).

Mc Guire investigates the market of the ceramic product, and finds that, the builder have begun to use it for its durability and appearance, but the only negative aspect is its high cost. Because of that, architects in the United States have discovered porcelain stoneware, which provides the same long-lasting appearance and

durability at a far lesser cost. That's why architects consider it the logic alternative (1991).

Because ceramic tiles look so good, many people consider it as a luxury product. Actually, it is affordable. When compared to vinyl flooring, many ceramic floor tiles are about the same price, and in the long run it is much more economical. Tiling a wall is more expensive than wall paper or paint, but tiles are more practical in many locations. An important consideration when comparing the benefits of these products is the return for the money. Therefore, a proper installation of tile will add value to the house ("Benefits of Ceramic Tile", 1998).

Tile is usually acquired by the square foot, not by the piece. This is useful in comparing the prices between different sizes of tiles. It is interesting that, the cost or installation can be as much as, or more than the cost of the tile itself. That's why, choosing a less expensive tile will not help to save so much ("RBC Installation Guide-Selecting the Right Tile", 1998). As a result of these, it can be said that, for a bit more money, ceramic tiles bring style and versality underfoot.

2.2. Selecting and Specifying Ceramic Tiles

Ceramic tiles are everywhere, but the important point is the reason. There is not any single reason that it has become the choice of many specifiers, architects and interior design professionals. But perhaps, a combination of things tend to turn end-users more toward ceramic tiles today, than in the past.

According to Mc Ilvain, knowing how to select ceramic tiles is important to architects and owners for aesthetically pleasing and long-lasting tile installations (1992). Siegel thinks that, the use of tiles in architecture has been governed by both their decorative and practical appeal (1989). All ceramic tiles are not equal and some are more suitable for use on floors or walls than others. Like other building materials, ceramic tiles have capabilities and limitations that must be considered when specifying and installing them.

The ability of a material to resist stress plays an important role in the selection process. When choosing a material, it is advisable to consider test data for the characteristics of the material selected. Every material has, or should have, an identity card containing technical data that show the results of resistance tests. These data can be useful to the designer, but they should refer to tests scientifically made in qualified laboratories. Knowing the results of these laboratory tests is indispensable in determining the static calculations of a particular material as shown in Table 2.3 .

Table 2.3. Important Categories To Consider In Test Data (Corbella, 1989:59).

"**Stress**	**Specific resistance properties**
Wind action	Flexion, elasticity
Load on structure	Density
Heat absorption, thermal range	Expansion rate, freezability
Humidity, frost	Moisture absorption, freezability
Anchorage systems	Flexion, impact, microhardness
Earthquakes	Flexion, compression, elasticity
Atmospheric agents and pollutants	Resistance to chemical agents"

According to the table, for example if there is the stress of wind action in the area, one should look for the flexion and elasticity of the material, and so on.

Standards for both fabricating and installing ceramic tiles are published by American National Standards Institute (ANSI). Tile is tested uniformly by the methods of ASTM, so that comparisons between products can be made, and their suitability for a given project can be determined (cited in Mays, 1989:93). Destructive tests are used to determine water absorption, crazing, thermal shock, bond strength, breaking strength and abrasive hardness. Non-destructive tests include thickness, facial dimension, warpage, wedging, colour uniformity and electrical properties (Zelinsky, 1995). Architects have great interest in these tests which are especially about porosity (water absorption, frost resistance and chemical resistance), dimensional accuracy (thickness uniformity, facial dimensions, warpage and wedging), and wear resistance (resistance to scratching and abrasion). Further tests include breaking strength, bonding strength and slip-resistance. Although there are some exclusive tests, European Standards also exist for most of the ASTM categories (1989).

Many of the most common complaints about interior projects relate to materials that fail in one way or another-that break, wear out, attract dirt, hard to clean and maintain, or in some other way create problems that could have been avoided. Pile states that, these problems can be guarded against by using a mental (or actual) checklist in evaluating each choice. Materials are usually chosen to satisfy their primary role- a floor material to be practical to walk on; a window material to admit light; a door material to provide closure. Problems are most likely to arise in

connection with secondary criteria, which may be overlooked if one focuses on primary function and appearance alone. An otherwise satisfactory floor material may become dangerously slippery when wet; an attractive wall surface may become marred easily and be hard to clean; carpet selected for attractive surface and color may show dirt and wear (1989). Therefore, it is an important part of the interior designer's work to be careful in such issues and to deal with them by learning all of the characteristics of the materials chosen. Designer must consider three types of criteria while making his choice, as depicted in Table 2.4.

Table 2.4. Checklist Of Criteria For Material Selection (Pile, 1989:108).

FUNCTIONAL CRITERIA
Primary: Suitability to basic utilitarian purpose
Secondary: Durability in anticipated use.
Ease of maintenance, repair, cleaning
Resistance to damage and vandalism
Safety characteristics (accidents, fire)
Acoustical performance
AESTHETIC CRITERIA
Availability of desired natural or applied colors
Textures
Possibilities of pattern
Visual suitability to intended function
ECONOMIC CRITERIA
First cost
Lifetime cost in relation to expected durability and estimated cost of maintenance, cleaning, repair, and future replacement

According to designer Katherine L. Freeman, architects' and interior designers' first consideration in selecting a flooring material is the aesthetic quality of the material itself. Design professionals consider two things while selecting a material.

First one is, whether the color, design and scale works with the overall design concept for the installation; and the second one is whether the texture and appearance co-ordinates with other elements of the design. With these aesthetic considerations, design professionals use their skill and training to select materials that create a finished, beautiful design. After identifying the flooring materials that are suitable for the design of the project, than the designer must determine whether the flooring materials are appropriate for the installation. This is required to understand both the performance and aesthetic characteristics of the flooring material (1997). During her career as a designer, Freeman considered some performance characteristics in evaluating whether a specific flooring product would be appropriate for the installation that she was designing:

"1. Static Coefficient of Friction

2. Water Absorption

3. Breaking Strength

4. Bond Strength

5. Abrasion Resistance

6. Moh's Hardness" (1997:14).

According to Zelinsky; to specify ceramic tiles for interior projects, a designer must know the materials and have a knowledge of basic installation techniques, but above all must understand how to choose the right tile for the right application (1995). For many consumers, the purchase and installation of ceramic tiles are often big investments. That's why it is so important to know how to properly select the right tile for the right application. These are just some of the key questions that Monari suggests to keep in mind when selecting ceramic tiles:

- "How much traffic will the floor or area endure?
- How will the tile be used (for floor, wall, or other surfaces)?
- Is the tile being used in a wet or dry area?
- Will the application require slip-resistance coating?
- Is the tile for indoor or outdoor use?" (1996:20).

As Monari has written, first, the amount of traffic a floor will encounter must be considered while selecting the material. As tile is available in different finishes, sizes, durability ratings and textures, one needs to select the proper tile for the proper usage. Kitchens, for example, are high traffic areas for cooking, eating and socialising. A floor here will require a heavier-body tile than one used in a bathroom due to the traffic, food spills and the dropping of pans and other kitchen items. A tile with the durability rating of "4" would be sufficient for this area, while a durability rating of "3" is more appropriate for bathroom. Secondly, the physical qualities of tile must be investigated, according to that specific area. For example, in kitchens, sharp-edged utensils and heavy cooking items are found, calling for a tile that is more impact resistant, meaning that the body of the tile is more compact to ward of scratches and chips, and less porous for stain control. Next, designer needs to know the differences between glazed and unglazed tile. Glazed tile is best for residential applications because it is durable to household stains and it is also easier to clean, on the other hand most unglazed tile, because of its high porosity, is more like to stain when oil or other liquids are accidentally spilled (1996). About the same subject, Mevius states that, characteristics of today's ceramics, both glazed and unglazed, make them suitable in many ways to other

floor and wall treatments. Health and safety are also important factors when selecting materials for either residential or commercial installations (1997).

The variety of ceramic tile products is almost endless. The user is limited only by his imagination in the selection of products for residential or commercial use. Siegel points out that, having so many tiles to choose from, can cause another problem, which is deciding colors, textures, sizes, and shapes, best suited to the decorating needs. According to him, decision depends partly on the decorating goal and partly on one's own style preferences. First, what the tiles can do for the project must be considered:

- Are they going to create a dramatic center in the room or to serve as a backdrop for the furniture and fabrics?
- Will they used to hide an awkward element in the room or emphasise an architectural ornament?
- Do they wanted to increase the sense of space in an area, or to diminish it?
- Is the aim of the project to unify disparate areas, or to point out the sections of a shapeless space?
- Are they going to be used to emphasise the horizontal or the vertical, to lower the ceiling or raise it? (1989)

Another important thing for Siegel is, looking at the overall interior design of the apartment or house. If the interior design has an overall theme or style, this may be wanted to be emphasised in the tiling project. Before making the final choice, it is important to be sure that the chosen tiles are suitable for that particular area. For example, if they are for a patio or pool and the temperature in this area is likely

to go below freezing, tiles must be frost resistant. If they are going to be used for a kitchen counter or bar, tiles have to be acid resistant (1989).

Another important point is to select the correct type of tiles for the walls and floors. At this point the amount of wear that the area is going to receive must be considered and tiles must be selected accordingly. After being satisfied with the stress and wear requirements, the next problem is deciding how many tiles are needed and how much it will cost. Cost is related to the number of tiles which is related to the size of tiles. Somehow, all considerations have to be mixed together to come out with something affordable (Siegel, 1989).

A wide variety of hard surface flooring materials are available for designers to select and specify. Designer can use the performance characteristics of different hard surface flooring products to achieve a harmony between design and performance, creating proper and attractive installations for their client (Freeman, 1997).

The practicality, style and design of the tile that complements its surroundings, need to be equally considered. There is no need to sacrifice beauty for practicality or function. If properly selected, tile can both aesthetically please and technically perform for years ("Lifestyle is Tile" ch05, 1997). According to Vogel, the mood of the decoration of a home or remodelling project can be set with ceramic tiles. Today's homes are more individualistic and relaxed than ever before, and they show a new concern for convenience, the environment, health and safety. Ceramic tile is an important part of this new thinking and play an important role in

transforming an environment into a beautiful, warm and secure place (Vogel, 1997).

2.3. Installation Methods of Ceramic Tiles

Properly selected and specified ceramic tile installation methods are the first step in obtaining high quality, long lasting, and aesthetically pleasing ceramic tile installations. If not properly installed, it has no importance to choose the right tile, as there will still be defects because of wrong installation. That's why it is important also to make workers learn the characteristics of the material, and how to install them properly. Only by that way, long lasting and proper installations can be obtained. Mc Ilvain observed that, according to Tile Council of America (TCA) life cycle cost studies, properly installed ceramic tile floors and walls last as long as the life of a building, at lower overall costs than other finishes (1992).

Zelinsky explained that, there are two methods of installation of ceramic tiles, which are thick-bed and thin-set. They may be used depending on the condition of the surface, the space, the clearance allowed, the skill of the installer, and the client's budget. Each method requires its own application techniques and each has an appropriate role; the designer should be familiar with how, and when, each may be used. In the thick-bed method, tile is laid over a cement bed up to two inches thick, so the floor must be able to hold the combined weight of the cement and the tile. Thick-bed installations, while raising the floor level slightly, also worn surfaces that may have settled into angles. They can be used to define slopes or planes on the finished tile surface. In the thin-set method, tiles are bonded directly to an

existing surface with a thin coat of mortar material. Its advantages are a thinner profile, lower total weight, and less labour time. The surface must be level and round (1995).

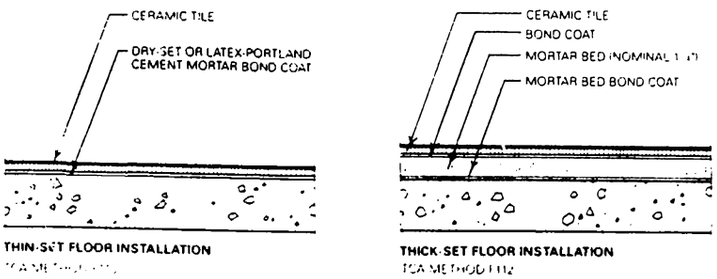


Fig. 2.1. Thick-set and Thin-set Installation Methods .

Mortar is the bonding material used to install ceramic tiles. The type used will depend on the method of installation and the need for waterproofing, soundproofing, chemical resistance, or electrical conductivity. Grout is the material used to fill the joints between the tiles after they are installed, and it is available speckled or in a wide range of colors. There are different kinds of grouts, for different applications. Zelinsky explains these as, sanded grout is the one with sand added, and it is used in wide joints to control shrinkage cracks. On the other hand, unsanded grout is used for thin joints. Latex-modified grout absorbs less water, so it offers improved stain and freeze-thaw resistance, also eliminates wet curing. Epoxy grouts are more stain resistant, less porous, and have better chemical resistance against acids and alkalis. Because of that, they are preferred in kitchens and food preparation facilities. If a kitchen or a bathroom is going to be tiled, a waterproof grout must be chosen (1995). Mc Ilvain states that, designers have to select grout colors carefully for floors subject to staining or poor maintenance. Natural gray, dark gray, or black is a good choice in commercial

kitchens, as grease and food spills will darken the light colored grout. Colored grouts enhance walls and floors subject to normal use and maintenance (Mc Ilvain, 1992).

It is the responsibility of the architect to specify expansion and control joints and show their location and details on drawings, yet some experts say that expansion joints are often left out of the plans. Zelinsky gives the definition of an expansion joint as a space filled with an elastic material that will accommodate expansion or contraction of the tiles avoiding the cracks. Such joints are made of flexible and compressible strips of closed-cell foam polyethylene, butyl rubber, or open-cell and closed-cell polyurethane rounded at the surface. Expansion joints are important in rooms more than 12 feet wide, where interior tile work is exposed to direct sunlight or moisture, or where columns, pipes or materials with different coefficients of expansion are within the tile. If attention to expansion joints is not given during installation, the tiles may pop up or crack because of contracting and expanding slab (1995).

Curing is the process of allowing a new tile installation to set. Tile should set for at least 24 hours before grouting. Grout reaches 90% of its strength in 28 days. So, all traffic should be kept off a newly tiled floor for 72 hours after grouting, unless otherwise is recommended by the manufacturer. Quick setting mortars and grouts can be used to speed up the process. Some installations will benefit in strength and durability by "damp curing", in which the humidity and temperature of tile installations is controlled for proper hardening of setting materials, by covering the tile installation with damp cheese cloth or damp saw dust (Zelinsky, 1995).

3. CERAMICS IN ARCHITECTURAL DECORATION

Ceramic tiles have long been selected by the architects, designers and builders because of their naturalness and unlimited colors, richness and luxury, which make a great effect on the observer, with endless design possibilities and unlimited creative opportunities (Savio, Feb.1991). Its durability and versality are other important factors in order to provide endurance, strength and longevity ("The Directory of Design and Decoration", 1997).

Today's homeowner, architect or interior designer can easily find a ceramic tile to beautify any indoor, outdoor, home or business setting. This can add comfort and beauty to the environment in a practical and low maintenance way. Inside and outside, ceramic tile is a good choice for both residential and commercial settings ("Lifestyle is Tile" ch.03, 1997). As all types of materials have different characteristics, each of them is suitable for for different applications. Table 3.1 shows the primary applications for different types of ceramic tiles, depending on their particular characteristics and considerations.

Table 3.1: Primary Applications Of Ceramic Tiles ("Guide to Ceramic Tile", guide10, 1998).

Surface Finish	Type of Tile	Primary Applications
Glazed	Clinker	Interior floors, exterior walls, and floors
	Cottoforte	Interior floors
	Earthenware-White body	Interior walls
	Majolica	Interior walls
	Red body-Single fired	Interior and exterior floors
	White body-Single fired	Interior and exterior floors
Unglazed	Clinker	Interior floors, exterior walls, and floors
	Impervious stoneware (Porcelain tile)	Interior and exterior floors
	Red stoneware	Interior and exterior floors
	Terracotta	Interior and exterior floors

Also for commercial settings, architects and interior designers use ceramic tiles to create attractive effects for all types of commercial structures, such as hotels, hospitals, subway stations, city halls, schools, restaurants, malls and plazas. As a flooring material, tile is durable against heavy foot traffic, and wear from car and truck tires. Benefits of ceramic tiles brought by the development in ceramic technology, helps architects and interior designers not to give up good style and fashion for high performance ("Lifestyle is Tile" ch.03, 1997).

3.1. Interior Decoration

As there is a large number of choices for ceramic tiles, there will certainly be a color, style and finish that is suitable for any interior design theme. From this point

of view, one of the most important benefits of ceramic tiles is its adaptability to play either a major or a minor role in a design scheme.

It is examined that, a great variety of sizes and colors, formatted in graphic combinations can help to complete a design theme, doesn't matter what the area is. Tiles of similar colors with different textures allow for nice, and also sophisticated installations. Depending on the style that is wanted to be achieved; from Early American, Classic, Victorian, to Post-Modern, Art-Deco or Urban Chic; there is a suitable tile to choose for creating drama or nuance. For example, if a style from the past is desired to be created, there are aged-looking tiles in various sizes to make this possible. There are also 3-dimensional wall tile trims to highlight areas, with or without complementary wall tiles. If the specific color or decorative tile still can not be found, there is always a tile artist, who will create the best design for the customer's dreams ("Lifestyle is Tile" ch.02, 1997).

The art of interior design can change with individual tastes, but the design must be planned properly, as the tiles cannot be easily removed. One must be careful in choosing tiles, because the design must be satisfying for years. There are not any firm rules in selecting size and shape of tile. However, there is an important point to mention that, it is not always true to choose small tiles for small rooms, and large tiles for large rooms. There are so many factors to make that assumption, such as angles and obstructions, function, style, mood, continuity, directional lines, rhythm, proportion and balance ("Lifestyle is Tile" ch.04, 1997). Monari also excepts this common misconception, and adds that, large tile can be used to

create the sense of more space in a small room, because of the less number of grout lines breaking up the space, so the room will appear larger (1996).

In most cases, there is consensus that, it is better not to use the same size tile both on walls and floors. This type of designs require that the floor and wall tiles line up, which is nearly impossible because of the imperfections of construction. Maybe the best choice is, to choose different sizes for walls and floors. On the other hand, there is another solution, that is installing the floor tile on the diagonal, which also eliminates the need for wall and floor tile alignment.

3.1.1. Wall Tiles

Tiles have been used to face and decorate walls for hundreds of years. During this time, they become a part of architecture and also a part of design scheme. According to Treister, by the development of ceramic tile industry, increased size offers a lot of advantages, so that much more graceful design statements can be made. Due to these tile designs, interior design possibilities increase proportionately (1996).

As can be accepted by everybody, decorating with wall tile creates an exciting world of color and design. There are attractive patterns and tasteful effects, bold geometrics and classic motifs designed by fashion designers and architects. The possibilities are endless.

They are lighter and thinner than floor tiles, and used primarily on interior surfaces, like walls, countertops and ceilings (Sunset, 1983). But some of them can also be applied on floors, with light traffic. At that point, Monari states that, it is not recommended to use wall tiles on floors, because the body is much thinner and wall tile has a durability rating of "1" or "2" (1996).

The purpose or function of the interior will determine the durability of wall material choices. Impervious materials are needed in heavily used areas, but little used areas can accommodate more fragile treatments. In the areas, where high levels of humidity, moisture in the air, smoke and fumes, airborne oils or dirt are of concern, non-absorbent materials are needed. Nielsen and Taylor think that, the material, that suits all these principles is certainly ceramic tile (1994). For many years, it has fulfilled this criteria with such economy and durability, that few other options are ever considered (Dean, 1985). The characteristics of ceramic wall tiles are investigated by the standards ASTM C 34-96, ASTM C 56-96, and ASTM C 212-96 (see Appendix A). Wall tiles are generally used in bathrooms, powder rooms, in solariums, exercise rooms, breakfast nooks and fireplaces. About tiling a wall, Siegel states that, it is not necessary to tile the whole room or even a whole wall. It will be better to tile hallways and corridors, one-third, one-half or even two-thirds of the way to the ceiling (1989).

Most of the tile guides suggest that, there are not so many restrictions when choosing ceramic tiles for walls. But Siegel points out that, although it is an enough reason to use ceramic tiles on walls because of its beauty, the other

characteristics, such as durability, ease of maintenance, make it suitable for a large number of areas (1989).

3.1.2. Floor Tiles

The floor is often the largest area in an interior, so its design functions must be considered properly. Designers have proved two things, that one of them is, the same visual excitement and intensity found in other surfaces can make the floor design lively, and the other one is, floor has an important meaning in contemporary design schemes. While the qualities of tiled surfaces may distinguish them as an overall practical and durable flooring material, ceramic floor tiles can be used also for architectural and decorative advantage. Tile is attractive, because of its ability to shape space, and then to beautify it. A tile may be used as a single decorative unit, while they may also be used to create a larger pattern or a pictorial mural rendered in tile. Or, the tiles used elsewhere in the interior, can be repeated on the floor in a different pattern, both for aesthetic unity and diversity (Busch, 1988b). By combining different color tiles, various patterns can be created, or separate areas of a room can be defined. Same effect can be achieved with decorative tiles. When surrounded by furniture, these tiles can be used as scattered accents, or they can give the illusion of colorful carpets and rugs ("Guide to Ceramic Tiles", guide3, 1998).

It is so important to have the flooring in mind, while decorating a room or a house, because the stresses are most applied on floors. The architecture, the furniture, the lighting, owner's preferences, the function of the floored area, and even the

geographical location must be considered totally. Customer's satisfaction is both based on the aesthetic result, and product's duration. Echard thinks that, ceramic tiles are fastly becoming the first choice in many parts of newly built homes as well as remodelled ones, with easy maintenance, durability, large scale of colors and design possibilities (1996). Busch supports this idea, and adds that, the visual vitality and creativity is being translated to floors, but architects and designers must keep practicality in mind as well (1988b).

While making a design of any place, the finish materials specified for floors are often permanent selections. Flooring materials are divided into three categories, which are hard (brick, concrete, stone, tile, wood), resilient (cork, fabric, leather, linoleum, rubber, vinyl) and soft (carpet, rugs). According to this classification, ceramic tiles are in the category of hard floor materials, with several advantages:

- High strength and durability,
- Non-absorbent and impervious to soiling,
- Easy to maintain and clean,
- Tend to be "classics", with aesthetic appeal to last indefinitely,
- Have great variety of design possibilities (designer can create interiors that are formal or informal, structural or decorative, textured or patterned) (Nielson and Taylor, 1994).

Besides all these advantages, there are also some disadvantages of hard floor materials:

- High initial cost,
- Special preparation,

- Cold underfoot, unless heated artificially or by sunshine,
- Reflect sound and seem to amplify noise (Nielson and Taylor, 1994).

According to Buch, the application of ceramic tiles on the floor is a tradition, that is based both on pragmatism and decoration. The durability of ceramic tiles, their fire resistance, abrasion resistance and other special characteristics have made them ideal flooring materials for centuries (1988b). The standard of ASTM C 410-60 classifies clay floor tiles according to some of these characteristics (see Appendix A). Unglazed tiles have advantages for floor use, than glazed tiles, because they are less slippery and show wear less, since the color extends throughout the body. If glazed tiles are going to be used in wet areas, tiles with textures and matte surfaces is the best choice.

To be suitable for laying on a floor, ceramic floor tiles must be thicker than wall tiles, which makes them durable underfoot. But Echard states a phenomenon of taking the floor up the wall, which means using the same tile on vertical surfaces that is also being used on horizontal surfaces, that makes the demand for ceramic tiles at the retail level continue to increase (1996). Many tile retailers think that, ceramic tile is always a good choice, because it will stand longer than any other flooring material. And they also believe it will certainly increase the value of the place ("Types of Tiles", 1997).

3.1.3. Sanitary Ware

It is observed that, the designers found ceramic sanitary ware used in bathrooms an extremely useful material for finding the best technical and aesthetic solutions, mainly because ceramic materials are hygienic and easy to clean. The planning process of a bathroom must start with deciding the five main items of equipment; which are basins, bidets, water closets, baths and showers.

Today, there are two main types of basins, that are, wall-hung (with or without a pedestal), and counter-top or vanitory basins (Snow and Hopewell, 1978). Basins are made of different kinds of materials. Ceramic vitreous basins are the most traditional ones. They are extremely durable, hygienic and easy to clean; but also heavy and require strong support systems (Dean, 1985). The simplest choice is to use ready-made ceramic counter-tops with integral basins which are made to fit onto joinery fittings. A more attractive, but at the same time more expensive solution is provided by a ceramic basin fitted under the worktop; but this needs a high standard of workmanship (Snow and Hopewell, 1978).

The primary purpose of a bidet and a water closet, is of course the sexual hygiene. Water closets have a lot of different sizes and shapes. The pan itself can be made from fireclay, vitreous china or glazed earthenware (Snow and Hopewell, 1978). Vitreous china was used by the Victorians and is still the most popular and widely excepted material for the toilet bowl. It is durable, heavy, resistant to stains, chips and scratches, easy to clean and hygienic. Like toilets, bidets are also made of

vitreous china and they are generally sold in co-ordinated designs and colors (Dean, 1985).

Another major item of bathroom equipment is the bath. They are now available in a range of materials and many different shapes, sizes and colors. The most common material for bath is glazed fireclay. It has advantages and disadvantages, but if given precautions in installation, use and cleaning are considered, it is satisfactory (Snow and Hopewell, 1978).

Showers have become popular too, like baths in recent years, because they offer several advantages such as being quicker, more economical on water and fuel, and more hygienic. The shower tray can be also made of vitreous china and glazed fireclay. These are easily installed in combination with water-proofing of nearby walls by means of ceramic tiles or other finishes (Snow and Hopewell, 1978). The table 3.2 summarises the materials from which the main sanitary fittings are now made.

Table 3.2. Materials for Sanitary Fittings (adapted from Snow and Hopewell, 1978).

Sanitary Fittings	Materials
Baths	Porcelain enamelled cast iron
	Vitreous enamelled pressed steel
	Acrylic plastics
	Glass fibre reinforced polyester resin (GRP)
Basins, Bidets, WC's	Glazed earthenware
	Vitreous china
	Glazed fireclay
	Acrylic plastics
	Stainless steel
Shower Trays	Vitreous china
	Vitreous enamelled pressed steel
	Glazed fireclay
	Acrylic plastics and GRP

The porcelain enamelled bath is produced by fusing of powdered glass and other chemicals in layers onto the cast iron body of the bath. The result is a strong, thick coating of opaque glaze which is more or less permanent. It is an excellent material for baths, because of its durability, good appearance and available colors. Vitreous enamelled pressed steel baths are produced by ground glass, pigments and other chemicals, mixed with water and sprayed onto the pressed steel body of the bath, and heated 830 C to melt. The result is a material that is resistant to scratching, acids, damage and protects its glossy surface for a long time. Glazed earthenware was once commonly used for the smaller fittings, but it doesn't continue now. Although it was cheap, the porous clay under the glaze would swell with any water penetration. Vitreous china is the most common used material. In the process of manufacturing, a white body of a mixture of china clay, ball clay, flint or sand, and feldspar, is poured into a mould, dried, glazed and then fired.

This material is perfect for basins, WC's, bidets and up to a size of shower tray. While producing glazed fireclay, a mixture of deep mined refractory clays, which gives a thicker body with higher strength than vitreous china, is used. The material is heavy, and is being displaced by other materials. However, some unique designs are still made, including a one- piece shelf basin. Colored finishes are available in all these materials (Snow and Hopewell, 1978).

3.3. Exterior Decoration

Ceramic tile is a decorative element suitable for any environment, providing a strong personal character. While, as an exterior cladding, tile adds color and texture to a building's skin; it also adds richness and dimension to walkways and courtyards. Tile's colors, sizes, and even grid lines create proportion and scale. Tiles create a line of color, or make more exciting the continuity of scale and form. Tiles also add width and scope to the design to improve the human dimension ("Exploring the Heights", 1989). The characteristics of ceramic tiles make it an important feature in today's workplace. Tile creates an atmosphere of cleanliness, stability, and security for exterior projects also. There are tiles that have resistance to acid rain, soot, grime, and other airborne contaminants ("Lifestyle is Tile" ch.03, 1997). In the exterior cladding category, porcelain tile is considered to be the best choice. The reason is that, it is a tireless performer, because it is durable against moisture and unaffected by freezing and thawing. At ground level, quarry tiles, mosaics and unglazed pavers lead the way.

The Ca'Bianca Centre in Milan provides residential accommodation and also shop and office spaces, consisting of a number of buildings and area. These are the main building with twin towers, which is residential; and the two lower buildings with gardens, garages, pedestrian and vehicle accesses. The important characteristic of the whole complex is the type of material used both on the facades, patios, walkways and vehicle accesses; which is ceramic tile. Since the centre was built both for public and residential use, during the design phase it was insisted that the best material, which has high durability with little or no maintenance must be chosen. This shows that the only alternative was extruded clinker, a ceramic material having necessary protection against frost, acid rain and atmospheric agents. The color is uniform throughout the body to guarantee the resistance to wear. The same material was also used on all the outside walls, and pavings, the only difference was the size and thickness ("Ca'Bianca Residential Centre", 1993).

In the same manner, the architects of Brian Paul & Associates Inc. of San Diego were looking for a material to be used on the exterior of the building that would look as good as the first day it was put on, even after 20 years. Their one of the design problems was the high level of automobile exhaust and contaminants, so the material must have been easily cleanable. After some research, they found the true answer: Ceramic Tile (McGuire, 1991).

Van Lemmen states that, in the recent years, New York architects have discovered another artistic expression. By that way, colors of a brilliant hue started to take the place of monotonous dull grey and red buildings with brown sandstone and

marble. The materials used for this ornamentation are colored terracotta, tiles and faience (1993). Since then, they become one of the most durable and attractive building materials with the richness of design possibilities and infinite variety of color schemes.

3.2.1. Exterior Facades

Setti thinks a facade is like a building's dress, and it often anticipates its inner content (1993). Ceramic transforms this dress into a modern, actual and living work by its traditional values, physical and mechanical characteristics, and up-dated technologies ("IdeaBuilding: Architecture in Ceramics", 1993). Covering of facades is one of the applications of ceramic products. Ceramics, as a building coating, has been appreciated, and chosen as skin for different buildings with different architectural settings. With zero humidity absorption, color variety, resistance to all kinds of weather conditions, inalterability and easy cleaning; they are suitable for exterior walls of buildings (Figure B.2). Glazed porcelain exterior wall tile is designed to provide extreme protection against negative weather elements and cracking. Glazed porcelain exterior wall tile has taken the quality control, making it one of the very best products in China, and in September 23, 1994; it received the "Trustable" Certificate from Chinese Consumer Protection Foundation ("Glazed Porcelain Tile", 1997). Also standards of ASTM C 126-96, ASTM C 530-93, and TS 2902 studies the properties of exterior wall tile (see Appendix A).

The use of ceramic ventilated facades has increased in Italy and Europe, where ventilated walls are being used for a long time. In a bank building in Stuttgart, Germany; a ceramic ventilated facade giving a modern image, combining it with the surrounding buildings coated with classical stone coverings. On the building's inner floorings and the stairs, the same ceramic material have been used, but in smaller sizes. Also in Curtis Plaza in Warshaw, Poland; which is an important shopping and business center, the impressiveness of ceramics and glass represent an ideal matching. All these examples show that ventilated ceramic walls are gaining more importance, and their future is definitely interesting in the architecture of many countries, as they are able of different expressions even in extremely different environments (Setti, 1993).

In United States, glazed tiles were first used on the exterior of buildings in New York that had been built for artistic purpose. Architects, George and Edward Blum, used tiles on the outside of the buildings by combining glazed tiles with brick and terracotta. They also incorporated many of these same tiles into the lobbies, hallways and fireplaces of the buildings. Many of the architects preferred to enrich the rough and rigid surfaces with bands or plaques of ceramic tiles when a little color is needed. The use of concrete and tile in residential structures was seen in rural areas also. The post-modern architects have rediscovered the functional and decorative qualities of tiles, and use them on many of their buildings. The tiles are often plain white or of a single color, but after extended over a large area, they become an important part of the building's visual impact (Van Lemmen, 1993).

According to Mays, the most visible place where ceramic tiles are used is the building exteriors. Many architects have selected prefabricated panel systems, while covering large areas of building exteriors with tile. There are a lot of advantages of panel systems, which are reduced labour costs, greater quality control, tighter construction scheduling, faster shipping, and easier installation (1989). Prefabricated ceramic tile cladding systems offer a lot of aesthetic and functional choices, that are limited only by the architect's imagination. Colors, shapes, and sizes of ceramic tiles available for exterior cladding are almost unlimited. Mc Ilvain explains that, structural framing of tile panels is lighter than precast concrete panels and brick masonry. It can be shop fabricated under controlled temperatures through the whole year. There are no delays because of cold and stormy weather. They can be quickly installed, providing time savings and permitting occupancy of new facilities ahead of schedule and within budget. Another important point is that, as they are fabricated over metal studs, they provide a non-combustible exterior wall. The only disadvantage of prefabricated ceramic tile cladding is that, its use requires skills of four disciplines:

- "design/engineering,
- fabrication of light gauge steel framing systems,
- application of backer board/mortar beds and tiles,
- transportation and erection".

If there is something wrong with one of the four disciplines, the finished product will show deficiencies (1990:141).

As a cladding material, exterior tiles can be made frost proof, low water absorbent, resistant to the effects of acid rain and maintenance free. These characteristics of

exterior wall tiles are studied by the standards ASTM C 67-97 and ASTM C 212-96 (see Appendix A). Slip resistance and abrasion resistance are not essential factors. Tiles can also be used on fountains, garden walls, frame windows, doorways, and other architectural features.

3.2.2. Exterior Pavement

Outdoor pavement must be very durable against the heavy stress it must bear. The strength of the tile is especially important in paving large public areas, such as plazas, walkways, and recreational areas, because they are subject to heavy traffic (Figure B.3). This property is less important in private areas like homes and gardens, where aesthetic qualities have priority. Also the pavement must provide safe and comfortable walking depending on the weather conditions and ground slopes.

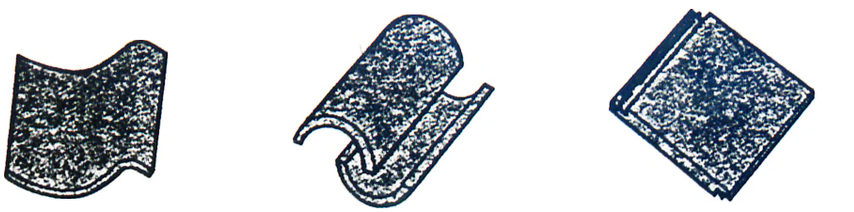
Ceramic tiles have the ability to tie the outside floors to the inside. As the origin of tile is nature, it looks great out in nature. If properly selected, its characteristics make it resistant to any climatic condition. Tiles for outdoors should be durable against the floor traffic, besides all other considerations, such as resistance to weather conditions, ease of maintenance and cleanliness, high mechanical load-bearing capacity, acid resistance, and abrasion resistance. Selecting slip resistant tile will provide a lot of advantages, besides a distinctive, long lasting beauty. There are other choices for outdoor tiling including unglazed pavers, glazed slip resistant tiles, and traditional quarry tiles. The characteristics of exterior paver tiles

are examined by the standards of ASTM C 902-95 and ASTM C 1272-95 (see Appendix A).

3.2.3. Roof Systems

The main function of the roof is providing a shelter over every building type, against sun, wind, snow or rain (McGowan and Dubern, 1985). That's why it should be impervious to rain, snow, and also be visually attractive. It should have resistance against destructive ultraviolet rays of the sun, and withstand high winds. Also, a roof must be fire resistant, because of the flying sparks released by the chimneys. Standard of ASTM C 1167-96 examines these properties of clay roof tiles (see Appendix A).

According to Landers, The type of the roof covering depends on the style and the locality (1986). In many parts of Europe, clay tiles replaced other types of roofing materials, because it is much more fire proof. Mc Gowan and Dubern observed that, originally, tiles were time-consuming and expensive to produce, but by the development of technology they are able to be produced more quickly and inexpensively now (Figure B.4). They also made a classification of clay roof tiles. There are three styles of clay tile. The first one is pantile with a slightly curved surface, made to overlap eachother like other roof tiles. The second one is curved tiles used in concave and convex rows (Roman tile). There is also interlocking tiles used on new houses and for roof replacement, which are laid in a single layer for weatherproofing (1985). The figure 3.1 shows examples of these types of roof tiles.



PANTILE ROMAN TILE INTERLOCKING TILE

Fig. 3.1. Types Of Roof Tiles

The clay tile is usually fixed to the roof with copper nails, as it resists corrosion and lasts as long as tile. A waterproof membrane can also be required under clay tile to prevent leaking (Kicklighter and Kicklighter, 1986).

3.3. Architectural Ceramics

Architectural ceramics is the combination of ceramic art and the architectural issues of space definition, ornamentation, and surface embellishment (Rubin, 1985). Busch states that, the importance of architectural ceramics in the history of the decorative arts is because of its ornament, rich geometric patterns and illustrative narratives which have decorated the surface and structure of architecture in practically all cultures (1988b). Architectural ceramics capture the essential part of an experimental age, where art and industry combine to create using nation's values in style and design ("Playing with Fire to Achieve Perfection", 1989). Ceramic architectural ornaments have not been discussed widely, even though the history of ceramics in architecture is almost as extensive as that of a simple clay vessel. Throughout the architectural history, ceramic work appeared as painted tiles and moulded and sculptural ornament in buildings.

The best examples can be seen in Islamic Architecture, from Central Asia to Middle East. In Anatolia, the Seljuk and Ottoman periods were the times, that the Turkish architectural ceramics have reached its top level. Carcanadec observed that, the Turkish architects conceived the decoration of the buildings at the same time as their construction. The ceramic facings were an integral part of the whole, not an ornamentation afterwards. The necessary ceramic tiles, with their motifs and composition, were projected at the same time as the plans and the materials of the construction. There was a concern to adapt the compositions to the purpose of the building, as well as to the surfaces to be covered (1981) (Figure B.5).

On the other hand, American architectural ceramics gained importance with the development of terra-cotta panels for exterior use. Terra-cotta offered an inexpensive modular building unit which could be moulded into many shapes. By the change in architectural styles, and the development of technology, the use and the variety of ceramic materials has changed also. The development of interior architectural ceramics in America is less impressive than that of exterior terra-cotta. Rubin states that, the early source of interior architectural ceramics were decorative architectural tiles produced in Massachusetts, and Moravian Tile Works located in Doylestown, Pennsylvania. Also architectural tiles of red earthenware with shallow relief decoration was provided for such sites as the New York City, Newark and New Jersey subways (1985). The production of ceramics for use in building was often the privilege of famous factories. The production traditions of these factories had allowed the construction of the wonderful tiling which covers palaces and waterways. According to Bosi, the reawakening of the use of ceramics for the decorative motifs in architecture came much later, that architects

tried to achieve new, unusual shapes, even if a certain ambiguity is fairly common. One of them was Antonio Gaudi (1852-1926), who decorated his buildings with multicolored ceramics which enhanced the stylised plant forms of his constructions (1993). One of the architect's most complete works, Casa Batllo is an apartment building in Barcelona, decorated with polychrome ceramics of both brilliant and subtle colors, which produces an indefinable sensation of lightness, in spite of the richness of forms and motifs (Figure B.6). Another marvellous work of Gaudi is Güell Park in Barcelona, that is created by so different and exclusive elements. Zerbst explains the park where, the wealth of bright, flashy colors catches the eye, but although they are not a part of the overall landscape, they fit into it harmoniously by enriching it without disturbing. A colored bench that leads round the square like some giant snake provides a generous space for different activities (1985) (Figure B.7).

Modular ceramics, which have a great place in architecture, is a part of architectural ceramics. Every module, prepared by hand, or mechanically in the factories, can be arranged in so many different ways to create aesthetically pleasing environments. They can be made in any size or shape, patterned or textured, by using every color, it is only limited by the imagination of the ceramist. Aesthetically, the relation between innovation and art expresses each culture's philosophy toward the decorative arts, the importance it gives to artistry in everyday life. Before the development of ceramic tile technology, tile classifications was simple; wall tiles were to be used on walls, and floor tiles were for floors. Today, the modern ceramic technology has produced a new generation of tiles against conventional forms. The variety of architectural ceramics is

because of the man's ability combined with technology, to create the elements of design ("Playing with Fire to Achieve Perfection", 1989) (Figure B.8).

Art is a part of architecture, and it should be. Aesthetics is an important fact that must be considered in every project, besides functionality. This effect of beauty can be obtained by architectural ceramics. A designer can create unusual, as well as straightforward settings with a fashionable style, by using the expressions hidden in ceramics. These expressions can be reflected by using elements of design to create attractive and proper installations.

4. CERAMIC TILES IN DESIGN

The desire to create order and beauty is a universal human characteristic. It is found in all works of art, architecture, graphic design, crafts and interior design. It is also present in planning, production, and use of ceramic tiles. This act of creating order and beauty is known as design, which is an active process that searches to organise parts into a satisfying whole. The design process considers both visual and functional points in creating something original and new. The best designs can be done by being both visually and functionally satisfying ("Lifestyle is Tile" ch.04, 1997).

Whether they are used indoors around fire places, on walls, windows or floors, or outdoors on garden paths, patios or pools, tiles can be one of the most exciting design features in home design. The variety and availability of this versatile decorating material is greater than ever. Siegel observed that, recent years have shown a rising preoccupation with surface and pattern in interior design with the increasing use of ornamental tiles as an integral design feature (1989). Because of these options, tile should no longer be an afterthought, but rather an integral element to be considered from the first conceptual stages of design.

Endless color, decoration potential, and basic characteristics of ceramic tile makes it a material for both construction and decor. According to Savio, they also offer touchable sensations that increase the pleasant aspect of the design, by

combining the glossy surfaces of enamelled ceramics with the rougher finish of terra-cotta (Feb. 1991). Like many other designers, Maurer thinks that, tile provides virtual unlimited possibilities in terms of styles and the development of unique patterns which points out the beauty of a commercial or residential project (1996). But besides this, Schein points out something important that, ceramic tiles are not a sort of make-up material, it is an integral part of the building (1991). They are rarely applied to flat areas, but they can also go around corners or cover three-dimensional forms, always stressing the architectural form (Mahmoudieh, 1991).

The size, shape, color and endless patterns of architectural tiles are used for both decorative and durable surface design. Besides their structural practicality, durability, and other characteristics, their most remarkable use is being ornamental.

4.1. Design Elements

Design is made up of some principles or elements. They include color, size, shape, pattern, and texture. These elements can be found in all acts of design, no matter it is sculpture, painting, ceramics or interior design. The character of the design depends on the combination of these elements. Ceramic tiles are also subject to these elements of design, like all created objects ("Lifestyle is Tile" ch04, 1997). There is a richness of design alternatives. While color, size and shapes are the main components, pattern and texture add a different dimension to tile design. Also grouting affects the overall result ("Guide to Ceramic Tiles", guide3, 1998).

According to Siegel, the success of any tiling project comes from combination of these elements into a coherent, well-planned design scheme (1989).

4.1.1. Color

The most powerful design element, and the most obvious characteristic of the ceramic tiles can be accepted as color. The color of a tile can create strong emotional and psychological responses based on culture and personal taste. Also visual effect of a color or combination of colors must be considered with these responses. The great popularity of ceramic tiles is because of its beautiful use of color more than other visual characteristics. Some manufacturers provide tile that is color co-ordinated with other tiles to simplify the selection process, and others provide tile colors to match with other materials such as plastic laminate, wallpaper, and plumbing fixtures. Except traditional colors, there is a great variety of colors for almost any decorating requirement. It is not difficult to find a range of options but it is hard to limit the choices and select an appropriate color scheme.

Siegel states that, choosing a color scheme depends on some factors such as: Favourite colors, the present colors in or near the room, or the fashion trends. It is true that fashion plays an important role in choosing tile color, that designers say they can choose colors by looking at the customer's clothes (1989). As tile manufacturers arrange their color selections to match fashion trends, current color schemes are easily created. If none of the standard colors are appropriate, many manufacturers can make custom colors. This depends on the square footage that

must be made per production run, and the quantity requested ("Lifestyle is Tile" ch.04, 1997).

Eczacıbaşı Karo Seramik company has created "Arkitekt Color" collection, to help architects about the problem of color design. The origin of "Arkitekt Color" collection is RAL color system (Figure B.9). By this way, advantages about color planning and combination are offered to every design of architects. This system provides recognition and communication of color differences, and also enables classification and combination of color. Color co-ordination with other products is another advantage of this system. RAL Design System is a physical color system based on CIE measurement method. A designation figure is obtained from the union of three different numerical groups:

"**First group:** H = Hue/Color tone

Designation figure with three digits: 080

Second Group: L = Lightness

Designation figure with two digits: 90

Third Group: C = Chroma

Designation figure with two digits: 20

Thus, the color designation symbol:

H L C

080 90 20"

The H designation value gives all the tonalities found on the relative page of the RAL-DS Atlas. RAL-DS Atlas includes 1,688 color tone differences based on color cycle of 39 pieces. The color cycle starts with red at 3.00h and is divided into 360 degrees. The reading is done counter clockwise.

"In Eczacıbaşı Arkitekt Collection, colors can be combined in;

- Same H group, for example

080 20 70 - 080 30 40

- Different H group but within the same or similar C group, for example

140 70 20 - 080 80 20

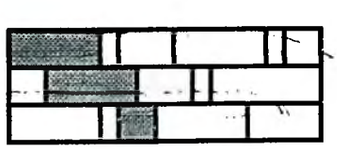
- Different H group but within same L group, for example

120 90 30 - 140 90 20"

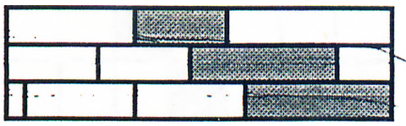
Arkitekt provides an interesting product range has been formed by presenting different color, size and surface combinations ("Eczacıbaşı Vitra Arkitekt RAL-Color Catalogue", 1997).

4.1.2. Pattern

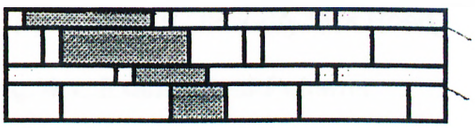
The modularity of ceramic tiles depend on the use of pattern. Infinite variety of unique patterns can be created by fitting together different types of tiles. It is a repetitive method of decoration and ornamentation. A plain, monochromatic tile installation can be transformed into an attractive surface alive with design by using a motif used over and over again. Floors, walls, countertops, stove surrounds, backsplashes, fountains, and pools are all excellent locations for ceramic tile patterns. These patterns are made by organising the size, shape, color and texture of tile. The following examples show some of the frequently used patterns:



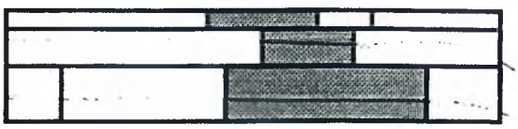
Short Joints with Fixed Width and Variable Length



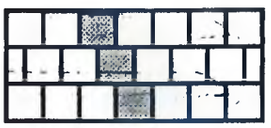
Long Joint with Fixed Width and Variable Length



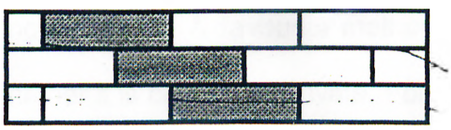
Short Joints with Variable Width and Length



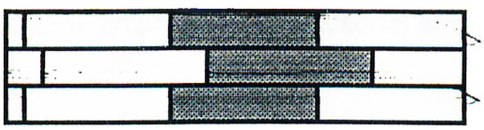
Long Joints with Variable Width and Length



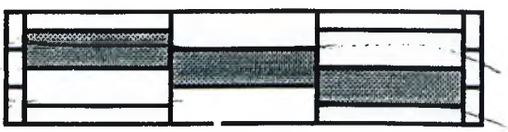
Square Pattern, Running Bond



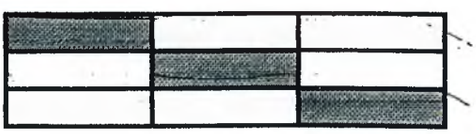
Rectangular Pattern, Short Running Bond



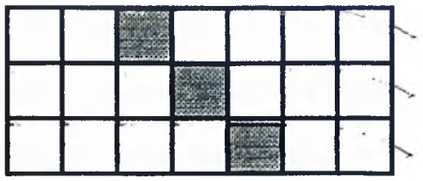
Rectangular Pattern, Short Running Bond



Rectangular Pattern, Long Running Bond



Rectangular Pattern, Jack-on-Jack Bond



Square Pattern, Jack-on-Jack Bond

Fig. 4.1. Examples of Patterns

Different possibilities can be created by using these elements both vertical and horizontal. Each will give a different effect.

According to some guides, there are some basic methods to create patterns, and each one has a different effect on an interior design scheme. Some methods are used to provide a visual focal point, while others act to combine the spatial composition or create a mood. It is also possible to use two or more methods in a single design. A favourite method for pattern designs is the use of symbolism, whether it is cultural or private. For example, in kitchens fruit and vegetable motifs express summer and harvests or gardening. On the other hand, geometric patterns emphasises a functional and efficient workplace ("Lifestyle is Tile" ch.04, 1997).

Siegel observed that, it has been thousands of years, since patterns of ceramic tiles have been used. While tile design reflects the taste of the times, it is also accepted as an architectural element. Many of the patterns have been made for hundreds of years by the same factories or even the same families. As a result of this continuation, tiles can give a historical or a traditional effect even to a newly built home (1989). Color and pattern are partners in creating mood. It is not important which pattern is chosen, but how the choice is done to distribute that

pattern in that space. The look that is wanted to be achieved, will direct how the pattern is used. Also, one must be careful in arranging the patterns, because the design must be harmonious, in order not to be boring and tire the eye.

4.1.3. Size and Shape

Size and shape add another dimension to the decorative potential of ceramic tiles. They are important elements to consider, as they establish the overall design scheme. The style and mood of a space can be changed by the simple manipulation of size and shape. Changes in size and shape are used to emphasise an element or add needed detail. These changes can be provided with or without changes in color and texture. Many manufacturers offer tiles in co-ordinated sizes and shapes to make creative designs. Figure 4.2 shows some examples of common sizes and shapes.

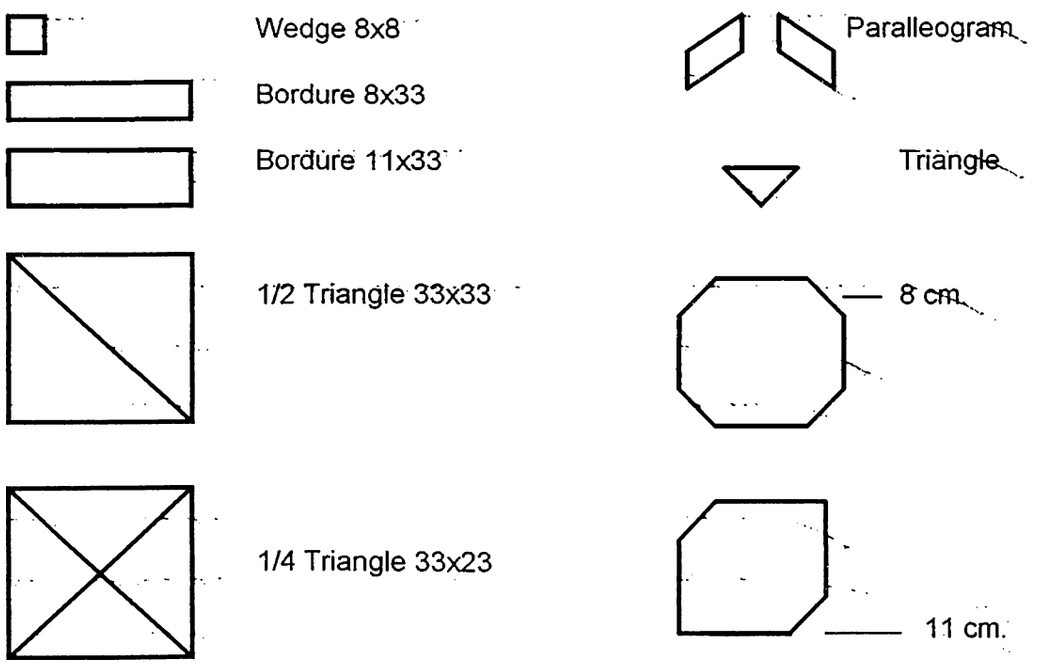


Figure 4.2. Examples of Sizes and Shapes (Seranit, 1997).

Pattern can be created by size, shape, and texture, which effects the look and feeling of the design. There are no specific rules about which size, shape, or texture of tiles to use in a room. But, there is one thing that, as it is mentioned before, it is not true to use small tiles in small rooms, as small rooms benefit from larger pieces of tile. Using small tiles increases the number of grout lines, which makes the pattern busier. Many small rooms may look better in larger tiles that do not visually break up the space into small segments. Many designers recommend mixing sizes to create a more interesting effect. Sigel points out that, from a practical point of view, it is better to have one size tile on the wall, and another on the floor. This is important because, if the house is not absolutely perfect, the two tiles will not line up straight (1989).

4.1.4. Texture

Texture, in other words the surface quality of a tile, improves the other elements of design: color, pattern, size and shape. Texture can make colors look more brighter, patterns and sizes can enlarge or recede, and the shape can be emphasised or made less prominent. Texture also affects the striking of light on tile, and how it feels when it is touched. It can even give a new, or an antique effect to the tile ("Lifestyle is Tile" ch.04, 1997). A great variety of decorative effects are possible by changing the texture of ceramic tiles.

Texture adds beauty, character, and a feeling of quality. Texture also creates the feeling of permanency in ceramic tiles. Textured ceramic tiles give pleasure to the senses with artful, modulating patterns of light and dark. Even some scratches and

small chips can add character to ceramic tiles, giving them a pleasing, antique look. Textures have a particular importance in interior design, as they add both physical and emotional comfort to the surroundings. Changes in texture add interest and variety to homes, since the changes affect the eye and give pleasure to the hand ("Lifestyle is Tile" ch.04, 1997).

Ceramic tiles have two basic types of textures: tactile and visual. Tactile textures can be felt, as they result from actual changes in plane (Figure B.10). The indentations of Victorian relief tiles, bright smoothness of glazed wall tiles, and gentle vibrations of hand-crafted terra cotta tiles can be given as examples of tactile textures. On the other hand, visual textures show the effects of texture through changes in light and dark. Many glazed tiles can be considered as visually textured, as they are perfectly smooth, and appear to have surface irregularities. Spots of color, suspended in the glaze, give this appearance of texture (Figure B.11). For example, faience tiles have nice variations in color that give the impression of roughness or depth. Texture should be considered while selecting tiles, as different textures and types of ceramic tiles may need different maintenance techniques and cleananbility ("Lifestyle is Tile" ch.04, 1997).

Siegel also examined the relation between pattern, surface, and texture. Surface texture can often be more artful than relief carving in three dimensions. For example, there is a great difference between the texture and feel of hand-made tiles and factory-made tiles. In hand-made tiles, each tile will be slightly different in color and shape, making the overall appearance different from the uniformity of machine-made tiles (1989).

4.2. Design Possibilities

For all kinds of tiles, the design possibilities are nearly endless. The decorative and architectural effects of tile, also show a wide range of design possibilities. The problem, while making a design is deciding how to use the tiles' elementary parts to form a composition on the entire surface. According to Pratelli, priority must be given to color and design relationships. For example, a square is rather insignificant, but it is a visual geometrical structure, capable of starting creative processes having extreme complexity (1997).

With the variety of designs and colors available, a ceramic tiles can be as decorative as one can imagine. Sizes and shades can be mixed to create artful patterns, and different materials or colors can be added. This arrangement can prevent the patterns from boring the space, and can provide a balanced appearance (Rees, 1983). Combining different size tiles to create a pattern is becoming easier with the increase of options to this effect. Small tiles can be used around columns and on curves walls, while larger tiles reduce the number of grout lines to achieve a more monolithic effect. Also borders can add architectural interest. New designs can be created by using ancient patterns, like Greek key design, stylised water motifs, curving floral designs, in order to give a nostalgic or mistic effect ("Lifestyle is Tile" ch04, 1997). Different colors can create space in homes as well as direct traffic flow in commercial areas. The highly reflective surface of many tiles can function as a light-enhancing element to brighten and enlarge small dark spaces ("Italian Tiles", 1989).

The wide range of ceramic tiles available today suggests some attractive variations on the basic decorating traditions since Renaissance. Traditional tiles can be combined with non-traditional patterns, and old designs can be mixed with new ideas for something unique and current. Tiles can be used to create new architectural elements in a room. Today most houses and apartments do not have many of the decorative architectural touches, like fan-shaped windows, carved mouldings, wainscoting and elaborate mantelpieces. Instead of these, square, utilitarian rooms and baths without windows often characterise this modern home. However, tile as architecture can recreate the effects of many of these traditional features. For example, three dimensional ceramic mouldings can add interest to plain walls, while tiling part of the way up a wall creates the illusion of wainscoting. Also designers can use entire murals to add visual interest and open up the space. These tiles, which have been used as architectural elements can be used with other natural building materials such as stone, slate, marble and wood (Siegel, 1989).

Choices for decorative use of tile have gone way beyond the all-white look. White tiles, still very popular can be made more attractive by using contrasting colors, or even tinted glass. The same things are also true for terra cotta ("Italian Tiles", 1989). The reasons for choosing terra cotta are; its past, traditions, and repeated use in mankind's oldest buildings. It is used for paving indoors and outdoors, where it can also become architecture, forming walls and arches, framing doors and windows. Natalini supports this, by stating that, this material's nobility and its cultural tradition make it important in restoration and restructuring projects (1991). For those who prefer a more crafty, country atmosphere, it is recommended by

most of the designers to use earthy quarry or terra cotta tiles, because thay create a warm, natural, and friendly environments.

The interest in architectural tiles is created by handmade, hand-decorated tiles, machine-made commercial tiles; or in some instances, commercial tiles that have been decorated by hand. Each of them create different effects. How craftsmen and artists shape and decorate tiles, and how these are then used by architects and designers is an important proof that an ancient decorative tradition is gaining a new interest. As each slab is made by hand, every one has slight irregularities in form, surface texture, and glaze. Each of them look different from eachother. Bucsh states that, the designs of these tiles can make for lively, representational murals, abstract geometric patterns, or more expressionist graphics. Many contemporary ceramists approach their work through architecture, textile design, quilt making, painting, weaving, and sculpture, that there is a rich design diversity to be found in handmade tiles (1988a). Handmade and hand-decorated tiles offer a natural and original look that is not found in commercial tiles. For more traditional interiors, the handmade tiles are a good choice. On the other hand, the flatness and perfect style of factory-made tiles can be a virtue in a modern high-tech setting (Rees, 1983). To create the feeling of modern style suited to the city with its high rise apartments and avant-garde architecture, factory-made tiles can be chosen (Siegel, 1989).

Perhaps the most attractive way about both kinds of tiles is their patterns. The obvious fact is that the tile need not to be square at all, because the possibilities of pattern are nearly infinite. Parquet, staggered brick, checkerboard squares and

squares on the diagonal, herringbone rectangles, and hexagonal stripes are only some of the more common patterns. Each of these can also be combined with eachother (Busch, 1988a). Pattern can be used both to highlight or isolate an element in a room, or as a unifying factor, it can bring all of the elements of a room together. A large pattern can attract attention more than a small pattern, however, depending on how and where it is used, a large pattern can either be a focal point, an accent or a highlight. For example, a tile mural on a dining room wall will create a dramatic center of visual excitement. The same pattern, however, can be used as an accent in the bathroom as a decorative base for the sink or a frame for the mirror. On the other hand, small patterns can form a texture that is soothing to the eye, when they are used all over the room. This time, the use of pattern allows other objects to act as focal points. A small pattern can also serve as an artful but effective accent, when it is used in combination with solid colored tiles (Siegel, 1989). An alternative to using patterned tiles to create a decorative floor is to built up a geometric pattern using a variety of shapes in different colors. There are some common methods for creating patterns with ceramic tiles:

"1. Combine different color tiles of the same size, shape and texture.

2. Combine different sizes or shapes that have the same color and texture.

3. Combine different textures or finishes of ceramic tiles that have the same color.

4. Use decorative ceramic tiles alone or combined with plain, mono-chromatic tiles.

5. Use decorative ceramic tiles in a mural design" ("Lifestyle is Tile" ch04, 1997).

A tile design with a dramatic effect will attract everyone who steps into the room. Drama is created by using bold color contrasts; risky, unexpected designs;

mysterious shadows; exotic themes and evocative suggestions. Position is important in creating drama. The space must be easily seen and uncluttered by furniture. The size and scale of the tile design should be such that it cannot be ignored. A unique dramatic design is one that nobody can miss (Siegel, 1989).

Although the variety and characteristics of ceramic tile make it possible to be used in every environment and design, this design should not be made randomly. The reason for this is, the disorderliness and too much pattern can kill a design, so simplicity is the best solution. Up to now, it is mentioned that, because of its aesthetic and functional values, tiles can be applied to any place and the design possibilities are endless. But, there is an important point, which is about the mood or feeling that ceramic tiles create in the environment. Every effect can be achieved by using ceramic tiles.

4.3. Effects on the Environment

In the hands of a designer, different types of tiles are mixed to create an emotional response, by soothing or stimulating designs with the agreement of architect's vision. The validity of a design must be measured by its power to perform. The soul must be satisfied, but practical requirements must also be recognised. When these two concepts combine, ceramic tiles offer the maximum solution. It can give life and color to any place, such as offices, showrooms, homes and industrial settings. As Bucci has written, in St. Enoch Center, the elegance and high degree of aesthetics achieved with the flooring is done by clearly legible patterns, which make this shopping center an especially pleasant place for visitors, who have no

difficulty following its internal routing (1991) (Figure B.12). In addition to being one of the most permanent and carefree surface materials on the market, ceramic tiles can create a different look that compliments many of today's popular decorating styles. More than aesthetic, and besides its beauty and durability, ceramic tiles can also increase the value of the home. They can also add personality to the environment, creating aesthetically pleasing environments ("Pro Flooring Center", 1997).

> Aesthetic integrity demands attention to detail. Each element must be carefully considered, each factor weighed. All must be in balance if the rhythm of the design is to emerge. Nowhere is the potential for conflict as great as in the arena of high-traffic commercial flooring. Provocative, but practical is the edict. Dramatic but durable is the dream. When dichotomy is all-pervasive, ceramic tile steps to the fore ("Floor Show", 1989).

Schein points out that, ceramic materials help to make volumes more expressive, introducing parameters that glass is incapable of expressing: color and decoration (1991). Tiles can manipulate the way space is perceived, to emphasise the horizontal or vertical, making us to perceive a room look smaller, or larger, higher or lower, by its ability to add and subtract height, width and depth in any area (Siegel, 1989). Because of that, tiles are appropriate for solving all decorating problems.

Color is probably the most attractive element in any room. Certain color combinations can create different feelings on the environment. For example; black and white express a high-tech, modern look, while pink and yellow creates a more delicate, romantic feeling. Combining pale colors provides a restful effect. Sharp contrasts, like black and gold, red and midnight blue, help to create drama. Also

some unusual color combinations, such as lilac and red, pink and green, can be exciting and a focal point in the room. Almost all color combinations can look good, if the components are of similar tone and value. The method of applying glaze color is can also create difference in feeling. Factory-made tiles look more precise, as their glaze is often uniform and sharp. This is different in hand-made tiles, that their glaze is not uniform, so the light hits the surface at uneven angles, creating a more rustic, informal look. Colors can also change according to their arrangement. A dark color placed near a lighter color will appear deeper, while the lighter color will appear brighter, emphasising the contrast between them. Strong, dark colors tend to make a large space look smaller and more familiar. Sharply contrasting colors are good for adding interest to a room that has fairly regular contours and furnishings that are not too busy. On the other hand, in a small or narrow space, pale colors can make the walls seem to move backwards. White tiles are particularly useful for hiding irregular shapes and proportions. Solid-color and low-contrast schemes are also useful in oddly-shaped spaces, and in spaces where the furniture and other features provide the prominent focal points. These color schemes can normalise the unusual, while making them suit to the overall interior design (Siegel, 1989).

Like color, pattern can be used to create illusions of space and shape. Siegel observed that, a pattern on a light background gives the feeling of depth. It helps to make a small room look larger, or the floor appear wider and longer. Patterns on a dark background tend to enclose a space. Patterns with strong geometric or directional lines create the effect of extending space. Width and length can be emphasised by setting tiles at an angle, as the eye will be drawn by geometric

lines in any direction. Pattern can also be used to break up space and to create a three-dimensional effect in a room. Deciding the amount and kind of pattern to use depends on the specifics of each tiling project. If the pattern's function is to emphasise a certain feature in the room, like surrounding a window, or dramatising an entrance, the pattern must be concentrated around those elements. As a unifying theme, pattern can connect rooms with related functions, attracting together what architecture has moved apart. For example, a border of printed tiles between a kitchen and a family room will visually link these two areas. In the same way, a baby's bath can be connected to the playroom by complementing patterns, or a hallway may become truly welcoming when it is joined to the entranceway by identical hand-painted tiles (1989). Echard says that, according to some retailers, some areas in the home benefit from both tile and carpet. An example is the dining room, where the carpet under the table can be kept, while creating a tile border around the table and into the walkway to the kitchen. In this way, tile has the potential of turning an ordinary room into something aesthetically beautiful (1996).

Exciting effects can be created by changing size and shape. Tiles can be set in different directions for different effects. For example, Siegel explains that, terra cotta tiles can create a rustic look when they are set on a diagonal, end to end for a modern look, and a diamond pattern for a Mediterranean effect. In the shape of hexagons or octagons, alone or mixed with different sizes and shapes, and even different tiles, terra cotta flooring is the most versatile of all the tile floors. A combination of triangular tiles, rectangular tiles, and square tiles of different sizes can be designed together like a puzzle, creating a rhythm of movement resulting from the directional lines formed by the tiles' edges (1989).

Different patterns, colors and shapes can be mixed together for a unique visual effect. Mixing different kinds of tiles can create a rhythm of color and pattern. Depending on the intervals of color and pattern, this rhythm can be either exciting or restful. Splashes of pattern will create drama, while single color tiles suggest calm. An irregular combination of patterned plain tiles will create more interest than a regularly repeated grouping. Stripes, solids, and grids can be combined to create designs that emphasise the horizontal and vertical spaces of a room (Siegel, 1989).

Size, shape and texture are especially good in creating illusions in a space. Shiny glazes create a more expanded sense of space than matte glazes. Mixing different textures can give the effect of depth and richness, even if the colors are muted. Shiny tiles can be used to brighten rooms that do not get much light, matte tiles to create a sense of warmth. Shiny and smooth tiles can be used to hide unpleasant angles or proportions of a room. Tiling one wall with a brilliant finish can extend the size of a room, while matte tile can make the walls draw closer (Siegel, 1989).

So, each design element (color, pattern, size, shape, and texture), help to create a different effect in an environment. They all work together for the same purpose. According to Siegel, tiles are such a traditional building material, that even the most modern ones can create a sense of the past, bringing some warmth into even the most hi-tech surroundings (1989).

4.4. Comments of Architects, Designers and Ceramists

In order to create more attractive designs, and point out the importance and position of ceramics in architecture, ceramists and architects must collaborate. The resulting works will not only exploit the potential of clay in architecture, but will also be more attractive than the works produced by architects working alone. Ferriday examined that, some artists and architects meet regularly to discuss concepts, aesthetics, and techniques. In these meetings, two objectives are decided:

- to explore the possibilities for the uses of clay in contemporary architectural settings,
- to examine the differing nature of the creative processes in art and architecture.

While architects are learning about the qualities of clay, the artists experience the necessary thinking required for architectural planning. Critics generally agree that architecture should understand the whole continuum of scales, from city-wide to pedestrian. Ceramists can extend the scale of a building into the range of human body, and at the same time through their understanding of the nature of a specific building material, they participate in the search for meaningful architectural form (1988).

Properly prepared specifications and drawings are the important link between architects' and designers' intentions and the distributors' and installers' beliefs in which they are required to provide. Generally, a ceramic design is considered after the project is done, if there are empty spaces to be filled. It is so hard to obtain proper results by that way, because every part of the design must be considered equally. Jess Mc Ilvain states that, architects and designers should include project

specifications and drawings for ceramic tile projects, in order to learn industry-recognised installation methods and avoid common installation problems (cited in "Profit by Design", 1997).

In recent years, Susan Tunick has believed that there is an important role for terra cotta in contemporary architecture, and architects need to be made aware of its' aesthetic potential (cited in Ferriday, 1988). She has also spent a lot of time working on Subway Ceramics. In one of her articles, she investigated three subway stations in New York. One of them is the City College Station, which has two interesting types of ceramic items, the first dating from 1904 and the second from nearly 1917. The earlier pieces are the cream-colored "137" numeral plaques, which were produced by the Atlantic Terra Cotta Company, which was responsible for much of New York's terra cotta architecture, and the work for 11 of the original stations. Terra cotta could be manufactured more economically than large plaques produced by tile companies. Terra cotta industry's another labour and money saving measure was the preparation of moulds which could be used in different situations. The second group of ceramic pieces are roundels which symbolises the seal of City College of New York. The other station, which was the subject of Susan Tunick's article was the Fulton Street Station, a part of the very first expansion of the original subway system. The ceramic plaques of this station shows how much the thick, matte glazes transformed the finished piece. The smooth detailing of the waves, paddle wheel and ship's railing have been hidden under a heavy coat of glaze. The third station was the Bleecker Street Station, in which cobalt blue glazed ceramic pieces make this station so different (Tunick, 1994).

In the renovation of Central Square transit station in Cambridge, Massachusetts, because of its hard, washable surface and abrasion resistance, glazed tile was chosen by Ellenzweig Associates of Cambridge. As the architect Gary Gwon says, their aim was to change the dark, dingy station into a radically different place. A range of bright colors and light were introduced with tile, also entry and exit points were emphasised by shifting to a deep blue. Three artists collaborated on the interior tile work. Artist Elizabeth Mapelli made the mosaic murals, whose colors and patterns relate to the traditions of various ethnic groups living in the area of the station. She selected glass-body tile because of its rich luminescence. Other artists Anne Stoors and Dennis Cunningham designed and produced 100 white relief tiles to install above the station columns (cited in Mays, 1989) (Figure B.13).

Ceramic artist Farley Tobin was responsible of decorating the Detroit People Mover transit system. In her initial meeting with the art selection committee, they only wanted bright colors, and the rest was up to her. She made a design both for passengers on trains and the ones waiting on the platform. A bold red "X" repeats regularly across the walls, giving the viewer on the trains the sense of a systematic pattern. For the people walking through the station, the shifts in color give a richness and variety of pattern that changes with each new perspective (cited in Mays, 1989) (Figure B.14).

According to architect Hundertwasser, the only one way to achieve stable, durable, clean colors in architecture is ceramics. But, it is important to know how to use them well, paying special attention to the strong features of the building, which

would make the material loose its special value (cited in Contratto, 1991) (Figure B.15).

As architect Rick Merrill states, achieving a quality look within a limited budget was the major concern in selecting the exterior cladding of two recently completed buildings in Dallas. While he wanted to use stone, the budget prohibited it, but tile also gave the elegance and feel of stone. He used the module of the tile to dimension the building, although different sizes were used on different planes of the building to emphasise their distance from the viewer (cited in Mays, 1989) (Figure B.16).

James Diaz, an architect from San Francisco, suggests that; tile don't have weight problems like precast concrete and brick. The California Medical Center in Los Angeles is located in a semi-industrial redevelopment area containing many old red-brick buildings. That's why, selecting a reddish tile helps this building to fit its surroundings. He also adds that, tile help to develop patterns that shift the scale of the building. At the same time, tile is very cost-effective over the life of the building, although it is more expensive than many materials (cited in Mays, 1989) (Figure B.17).

Architect Sergio Asti points out that, ceramic tile is a very rich material that he has always attempted to use, because of its quality, design possibilities, ability to highlight the quality of glazes and colors. He used several series of tiles suitable for different types of homes, where ceramics can create graphic designs with

perfect patterns and colors to become the most striking element (cited in Savio, 1991).

The Medical Exhibition and Marketing Center in Hanover, Germany, surrounds a large plaza covered with antislip and frost proof glazed ceramic pavers. The large area of the plaza, which also covers an underground parking garage, is divided into larger portions defined by a grid of extruded ceramic tiles. Architects Klaus Schuwirth and Erol Erman chose ceramic tiles over natural stone or clinker tile, to achieve a color similar to the green mirror glass used on the building facades. Also custom shapes were produced to be used in the decorative pool in the plaza and the rectangular planters on the building fronts. The load-bearing columns are covered with ceramic tiles that suit the others, easing the transition from horizontal to vertical elements (cited in Mays, 1989) (Figure B.18).

In designing the interior of the Shiseido Health Club in Tokyo, architect Michael Graves saw that ceramic tile, as a material which can be used in the pool area, was both virtually and functionally perfect. Graves realised the opportunity of being playful with water themes in the tilework, making the checkerboard band along the walls to change into a bubblelike scattering of tiles. Small fountains were used to add an element of sound in the acoustical environment. The highly reflective tiles were used around the entry to throw the reflections of the room, as soon as the splashing begins. Graves describes this effect of tile by saying, "That's the one thing about tile. It fairly dances" (cited in Mays, 1989:92) (Figure B.19).

Spanish architect Don Manuel Serra, the French site architects Auvrignon and Sacerdon have used ceramic tiles in lots of their projects, and discovered that ceramics were the ideal material for achieving ambitious designs. They all agreed that, tiles could make harmonious matches between styles with a certain amount of sympathy, although they were historically very separate (cited in Galletta, 1991).

Ceramic mosaic tile can be used to both express traditional meanings, or to deny them. At Trapper's Alley, a retail mall in Detroit, architects Roger Sherman Associates created the traditional character of the setting with patterned tiles and borders. Also, the same effect was created by architect John Catlin in the Daily Catch Restaurant in Cambridge, Massachusetts, by using ceramic mosaic tile installed in a pattern that ran up the wall and countered the room's geometry. Another reason of tile's use in both the restaurant and food service floor of the mall was its ease of maintenance (cited in Mays, 1989) (Figure B.20).

Designer Cindi Mufson is a strong admirer of the use of tiles. She uses tiles in every one of her jobs, not just for floors. The examples are traditional designed furniture, tops of tables, buffets, end tables, forms around seating, wall unit tops, and niches for art objects. In her own open-plan office, she used tiles to create separate areas. Rather than using contrasting colors, Mufson preferred a more artful textural approach by using a border surrounding a central area of the same tile set along the diagonal. Another designer Tom O'toole is very interested in the high relief tile. In a kitchen of the Kips Bay show house, he combined several different relief tiles in horizontal bands of various colors and shapes to create an architecturally interesting and easily cleanable backsplash. Another user of tile is

David Salamon, a New York designer, who thinks that tiles are exotic and they can evoke the feeling of a far away place. He likes tiles on everything, floors, walls and ceilings. He usually make his designs by mixing patterns within a room. Showers, lavatories and fireplace surrounds are other places where Salamon uses tiles ("Italian Tiles", 1989).

Ceramist Linda Blossom is interested in the use of ceramics to decorate homes. She is enjoying making pieces that fits to a particular site , home and owner. She loves to be free to choose the style and method that works best for a particular project. What she likes best in using ceramic tiles, is that they are permanent and can't be taken down and moved. By that way, she thinks they both belong to the house and the owner (1997).

Michael Wine, president of the Imagine Design Company, an artist and an architect by training, is studying the psychology of decoration by making virtual exact copies of the things from the nature in places where it doesn't naturally grow. His aim was not to create ceramic tiles, but to combine the recent advances in computer-aided graphics with architecture. He thought tile is the best medium, because of its permanence and durability. The tiles are produced using high-performance glazes applied like ink. Images are derived photographically, but more similar to a fabric pattern that has been repeated to produce an image not bound by grout lines. Images have been highly manipulating, computer designed, recolored, rescaled to create a surface effect that looks, as much as possible, like the real thing. Floor tiles include images of grass, water, stones, chili peppers and fall leaves in three standard sizes. He prefers large ones because of the less

number of grout lines. There are also wall tiles having images of pasta, daisies and apples. At the end of all these studies, all he wants to learn is, "What does it do to your state of mind, when your sofa sits atop a plot of perfectly manicured grass, or you step out of the tub onto a bed of river rocks?" (cited in Loukin, 1997:46) (Figure B.21).

A famous Turkish ceramist, Attila Galatalı's greatest ideal was to forge the links between architects in Turkey, and modern ceramic art. Most modern Turkish architects prefer either to design their own plastic decoration or leave it up to a craftsman, rather than commission an artist for the work. Attila Galatalı was disturbed by this situation, believing that modern interiors could only be created through coorperation between architects and artists. In his wall panels Galatalı captured the architectural dimension of ceramics, and reinterpreted traditional Turkish tiling in a modern discourse (Figure 22). Hamiye Çolakoğlu is another famous Turkish ceramist, who created attractive environments by covering the interior or exterior walls of the buildings, with architectural ceramics. Her works not only provided colorful cover for walls and livened up interiors, but performed functions which focused on the identity and functions of the architectural space. With their diversity of surface movement, her works neither usurped the role of interior space, nor let it dominate them, but lent energy and dynamism to their environments. From the point of view of an artist, it is important to consider that the ability of mastering the material has a great effect on the originality of the forms that will be created while using it. Hamiye Çolakoğlu is primarily aware of this fact. She starts working by considering both the artistic and the architectural results she is going to get at certain stages of her design (Figure 23). When it is

asked to Nasip İyem, a famous Turkish ceramist, about the relation of ceramics and architecture, she says there must be a balanced link between them, when it is thought about the need of ceramics in architecture. According to her, if the architect has chosen ceramics as one of an important part of his project, he should be in relation with a ceramist whose style is suitable for his design. But on the other hand, Iyem adds that, she never has been a witness to this kind of relation. She says, generally people think about ceramics after the construction of the building is over, not in the design stage. Because of this, she thinks that today's architectural ceramics are rarely beautiful and less suitable to the site. Another Turkish ceramist, Beril Anılanmert also thinks that, the use of architectural ceramics in Turkey is very less, when it is compared to other countries like Spain, Italy and Japan. She says there are some good works, but in general it is not so successful. She states, the increase in ceramic's areas of use is directly related with the development of ceramic industry. That's why the examples of ceramic tiles are better. Anılanmert believes that when the society become more skilled about this subject, requests and the approval level will increase (Figure B.24). About the same subject, when it is asked to İlgi Adalan, a famous Turkish ceramist, the answer is not so different: the use of ceramics in architecture is not sufficient. He thinks the reason for this is that, ceramics are generally used as gifts or daily used objects in Turkey. This shows that how people are uninscribed to ceramic art and industry (Figure B.25). Jale Yılmabaşar is one of the ceramists, who have a great success in architectural ceramics. She thinks the most important thing in ceramics is the technique, especially in architectural ones. According to her, there are a lot of points to consider while making a design (Figure B.26). A young ceramist İnsel İnal states his ideas about the relation of architecture and ceramics, by saying that

architects do not know anything about what ceramic tiles can do. Everything is possible (cited in Kapucu, 1997).

It can be seen that, both architects and ceramists have the common idea of accepting the ceramic material as a part of architecture, that the importance of it cannot be neglected anyway. Many architects and designers choose ceramic tiles in their projects, because they can provide every aesthetic and functional requirement. But, there are important points to consider, for making their projects stand out for long years, keeping its first look and durability. In order to do this, they need to take help from some guides or checklists to learn the proper applications of different types of material.

5. A GUIDE FOR ARCHITECTS AND DESIGNERS IN CHOOSING CERAMIC TILES

Too many times, both designers and specifiers have trouble about selecting a product at the last minute, only because of its aesthetic value without considering the durability and maintenance factors. It can be difficult to provide the balance between the design and specifying the right tile for the right application (Stanley, 1996). The important thing is, besides making aesthetically pleasing environments, designers must be sure to choose the proper functioning tile for the situation. Many of the most common complaints about the projects relate to the problems of inappropriate installations, or wrong material selection. It is not so hard to proove this, because one can see a lot of examples in daily life, like broken pavements, countertops that attach dirt or affected by heat, or floors that wear out, and other problems that could have been avoided. So, it is important to know the ability of the material to resist stress in that area. Therefore the first thing to keep in mind, before starting any installation, is to check the tiles' test ratings, and how they translate to the situation. After identifying how the area will be used and learning the test ratings, it is time to start exploring the creative options.

Since each application of ceramic tiles have a unique set of functional requirements, it is important to note the guides available to the designer for the uses of different kinds of tile. Concerning all these facts, this guide is prepared to

be useful in choosing ceramic tiles for the right applications, because selecting the product simply because of its design advantages without considering its properties and performance can leave a specifier exposed to a variety of possible installation failures. That's why it is important to know both the stresses on the floor and walls of the area, and the characteristics of the ceramic tiles that is going to withstand these stresses.

5.1. Areas of Use

Ceramic tile, that has an important place in human life with its various functions, has been extending the areas of use day by day. This is so natural when the different physical and visual characteristics of the material is considered (Baytuğ, 1996). Most architects usually are confused with the appropriate types of applications of ceramic tiles. This will no more be a problem when they get to know the complex structure and the properties of the material, because tile can be used everywhere. It can be installed on both horizontal and vertical surfaces, indoors and outdoors, doesn't matter if it is exposed to water or to high heat ("Benefits of Ceramic Tile", 1998). Surrounding ourselves with nature or natural things creates a sense of comfort and calm. Because of that the home, as our refuge from the outside world, has generally been decorated with natural materials. Ceramic tiles have the ability to add this natural feel to any living space perfectly ("Lifestyle is Tile" ch.01, 1997). Every room of the house can be virtually decorated with ceramic tiles, although it is most often used in kitchens and bathrooms. It is a practical floor covering in an entryway or living room, an attractive accent on stair risers, a maintenance-free surface on a table, and a decorative and durable

fireplace surround and hearth. Because tile is an efficient solar energy collector, it can retain and radiate heat when installed in a sunroom or green house. It can also be used outside to pave a patio, cover steps and risers, or to decorate a fountain or a wall ("Benefits of Ceramic Tile", 1998). In addition to the use of ceramic tiles in residential areas, designers also can use it in high traffic areas, swimming pools, commercial lobbies, new apartments, remodelled older commercial buildings, and operating rooms (Mays, 1989).

5.1.1. Residential Areas

The function of **entryways** is to control the circulation to different parts of a home (Kicklighter and Kicklighter, 1986). It is the part of the home that guests see first, so it should give a hint of the style of other rooms. The entrance takes the most intense household activities, with people constantly arriving and leaving, and also carrying the dust and dirt from outside. Because of this, the floor here must be wear resistant, and must not show dirt (Hicks, 1987). It should be durable, water and soil resistant, and easy to clean. That's why ceramic tiles are popular and durable floor treatments for this area. Also slip resistance must be considered, because of the mud or rain water that may come from outdoors (Figure B.27).

Halls are important elements of most homes. They provide main avenues for traffic circulation, and access to the different parts of the home. Everyone passes through the halls many times each day, so halls must be pleasant and functional (Kicklighter and Kicklighter, 1986). Halls must be designed to be resistant to a great deal of wear and tear, not just from one room to another but from outside.

That's why the floor should be tough and easy to clean, as well as stylish (Rees, 1989). Durability is of concern. Walls along hallways must also have resistant to wear and tear. Installing the right tile properly will make the floor easily withstand the foot traffic abuse, and it will keep looking great for years with minimum effort ("Lifestyle is Tile" ch.03, 1997) (Figure B.28).

Stairways can be decorated in order to add interest and enjoyment to living space. Stairs must be easy to clean, must not retain dust, dirt, and anything else that might cause slips or falls. The appropriate choice of material for stair treads is influenced by some factors: Structural considerations, type and volume of traffic, appearance, resistance to wear and sometimes chemicals and climate, ease of maintenance, cost, slip resistance, and how comfortable it is to walk on. According to Templer, coefficients of friction for slip resistance greater than 0.3 may be sufficient to prevent slips in interior stairs at normal rates of climb, but coefficient of 0.5 may be preferred for being more safer (1992). The materials for exterior stairs must endure rain, ice and snow, and resist to the long exposure of sunlight. Brick and tile are excellent and long lasting building materials for stairways, selected for their functions listed above, and also size, shape and color (Baldon et al., 1989). It is important for the staircase material to be fireproof, in order to provide the escape route from upstairs. When a material such as ceramic tile is chosen for stairways, they may also function as structural members as well as decoration (Figure B.29).

The **living room** is the main center of the activity for many households. People spend most of their time by using this area as a conversation area, a TV room, or

a place to entertain guests depending on the specific occasion. It may also function as a place for listening to music, reading, indoor games and hobbies (Kicklighter and Kicklighter, 1986). The living room is the part of the house that people spend most money, and it is important that the floor is one of the largest decorative elements in the room, so a wrong choice could ruin the effect of whole scheme. A material with poor quality will quickly look old and need replacing, and it may be difficult to live with it over the coming years (Rees, 1989). Ceramic tiles won't create problems like these. It will keep its first look after long years. A living room floor must be easy to clean, resistant to abrasion and wear, have a high rate of durability. If there is a fire place or hearth, it should also resist fire and heat, because of the sparkles coming out. Also the attractiveness of ceramic tiles combined with carpets or rugs will be pleasing to the eye (Figure B.30).

The **dining room** is the place dedicated for the process of serving and eating meals, after-dinner conversations and family celebrations (Expomueble, vol.1, 1991). The main point about the dining room floor is that, it must be easy to clean, durable and suitable for specific activities. It is an area that is especially subject to food spills and movement of chairs, so any surface which marks or damages easily is not suitable. Tile on a dining room floor is resistant to high wear, and maintenance free. Spills can be easily wiped away from a ceramic tiled floor (Figure B.31).

Kitchen has become a family living space, as well as a place for cooking where food is to be safely and hygienically prepared. The floor takes the most of the hard wear off all the surfaces in the kitchen. It must be resistant to grease, water, heat,

heavy appliances, and the foot traffic repeatedly standing in one place, or walking over the same route between appliances and storage areas. It must also be resistant to stains, easy to clean, hard wearing and non-slippery for safety. That's why, kitchen is the perfect setting for ceramic tiles. It certainly enhances the area, but its characteristics are what really makes it suitable for this room. There will be no residual stains on a ceramic tile floor, it will be resistant to household microbes and food bacteria, and the wear and tear of daily use ("Lifestyle is Tile" ch.03, 1997). As well as floors, ceramic tiles are also suitable for countertops. It does not burn, so hot pots can be put on countertops without scorching. Ceramic tiles are the most attractive, durable and hygienic surfacing materials for countertops, because they are also scratch and acid resistant, and do not chip easily ("Lifestyle is Tile" ch.05, 1997) (Figure B.32).

Bathroom is the room which influences the opening and close of our day, that is designed as multifunctional environments for different activities, such as bathing, relaxation, laundry, and even exercise (Lawrence, 1988). Floor carry the heaviest traffic, and the cabinets are affected by heat, moisture, acids and alkalis, walls are attacked by cleaning agents and grease, got wet by water and steam. A perfect bathroom material should be easy to clean and stainproof, hygienic, slip resistant, impervious to moisture, scratch resistant, heat resistant, aesthetically pleasing and reasonably priced. Ceramic tiles have all these characteristics, which makes it an ideal choice for bathrooms. According to Payne, the choice of materials for walls or floors depends partly on economics, and partly on aesthetics, but the most important, on practical considerations of durability, application methods and safety (1985). Ceramic tiles are durable against splashes and daily soakings, whether on

the counters, on the floor, on the wall, or around the bath and shower ("Lifestyle is Tile" ch.03, 1997) (Figure B.33).

Bedrooms are no longer just places to sleep, because today's lifestyles become more complex and personal requirements more changed, they gain an increasing importance. It is the bedroom that people dress, watch TV, or eat an occasional meal. It is also a refuge area when somebody is ill. If one is suffering from allergies, ceramic tiles can make sleeping more comfortable, as they do not absorb dust or odours. The space needs to be naturally comfortable, inviting, and functional. The floor covering needs to be easy to clean, hygienic, and abrasion resistant. Stuckin and Abramson states that, 20 years ago, tiling a bedroom floor was unheard of, but not so today. Ceramic tiles can bring these advantages to this space by the characteristics listed above (1997) (Figure B.34).

Patios, porches and courts extend the living areas of a home to the outdoors. They may be used for conversation, relaxing, playing, entertaining, dining and cooking (Kicklighter and Kicklighter, 1986). When selecting the material for the patio floor, there are some points to keep in mind. Firstly, patio paving should have a surface texture, that does not glare and is slip resistant. Secondly, the color and texture of the patio surface should harmonise with the construction materials used in the house and garden structure. Third, paving should be easy to keep clean and stainproof. And last, a good paving should be resistant to weather conditions, such as freeze, cold, rain, and so much heat in warm weather that you can't even walk on it. Ceramic tiles can give a patio either a smooth, and attractive look, or a rough and informal appearance. In both ways, their warm, earthy colors suit well with the

garden colors. Tiles are easy to clean, and resistant to stains, scratches, weather conditions and heavy foot traffic. Quarry tile or patio tile are most appropriate tile types for patios. In addition to these, a variety of special purpose and industrial tiles can be found suitable for patio use ("Sunset Patios & Decks", 1979) (Figure B.35).

5.1.2. Public Areas

One of the most attractive interior use of tiles can be found in the **subway system and stations**. Their designs are warm, rich and durable. The decision to cover the interiors of stations and subways is because of the technical and at the same time aesthetic requirements. A very hard material is needed with a high degree of chemical and physical resistance. It should have resistance to thermal shocks and sudden temperature changes, must resist atmospheric agents and acids, and be easy to clean. Van Lemmen states that, it must also be considered that how easily the bad habits of large city dwellers can make stations and subways become dirty and damaged. That's why the selected material should be durable and abrasion resistant. As ceramic tiles have all these characteristics, they are the right material for lining the interiors of the stations and subways (1993) (Figure B.36).

A **restaurant** or a **bar** has the atmosphere of sociability and liveliness. It is the place where people eat, drink, entertain, celebrate some occasions, and sometimes dance. According to Lawson, floors can be the same level throughout for easier circulation, cleaning and safety. The method of fixing flooring and cladding materials depends on some considerations. The floor of a restaurant or

bar must be both decorative and functional, besides being suitable for the character and intensity of use of the area. The decision must be done depending on the use and situation of the area, according to physical properties (1987). These are ease of maintenance, being hygienic and durable, resistance to acids, initial cost and time, and also the scope for future replacement. The floor covering must have tensile and flexural strength, where impact strength is necessary for wall linings and counter surfaces. Abrasion resistance is another important factor for all surfaces. Coefficient of thermal expansion, effects of moisture and humidity change must be considered mostly in kitchen, servery and toilet areas. Resistance to oils, water and chemicals are necessary for all areas exposed to contact with food and frequent cleaning. In areas for cooking, holding or heating appliances, resistance to heat and fire must be considered. Fire resistance is also important to prevent the spread of fire. In relation to the use of the room; resistance to traffic, wear, food spills, liquids, grease and stains are of primary importance. In circulation areas, like serveries, stairs and entrances, slip resistance is an important consideration too. The last requirement is the surface treatment, that the surface reflection must be provided by gloss, satin, matt or textured coatings. All the requirements above are found in ceramic tiles, which make them a perfect choice for restaurants and bars (Figure B.37).

Hotels are the centers of activity for the international crowd, whether they are business people, tourists, locals or hotel personelle (Berens, 1997). Hundreds of people come and leave hotels everyday, both clients and other people. That's why hotel lobbies are the areas where foot traffic is the most. In addition to comfort and function, the lobby emphasises the activities and qualities of the hotel's occupants

(Phillips, 1991a). More extensive use of tiles can be found in many of the hotels. Tiles have an important function in kitchens, bathrooms, hallways, lobbies, restaurants and bars. Previous considerations are the same for these, the only part that is not mentioned is the lobby. One of the reasons of choosing ceramic tiles in a large hotel is because it will not absorb unhealthy gases, both during installation or an event of fire. It is chosen for the commercial kitchen, because its impervious, hygienic, slip resistant surface provides an easily cleaned and safe environment for workers. The lobbies are the most crowded areas of a hotel, that greets every guest by its virtually attractiveness. When selecting tile for lobbies, it is important to consider mechanical load-bearing capacity because of the heavy baggages, ease of maintenance and cleanliness, abrasion and wear resistance, and high durability because of the continuos circulation (Figure B.38).

The first important thing about a **medical center** or a **hospital** is that, it should give confidence to the patients with its design and decoration. It should have a friendly atmosphere, and make the patient feel comfortable. According to Malkin, tables with cigarette burns, and dirty spots on walls and floors can tell the patient that the doctors do not care about their health and comfort (1982). Ceramic tiles are the ideal choices for every area of medical centers or hospitals because of their characteristics such as, being hygienic, easy to clean, resistant to acids, alkalis or other chemicals, resistant to heat and fire, durable, and slip resistant. They also do not absorb smoke or other gases, which provides a healthy atmosphere. Also Malkin states that, a suspended acoustic tile ceiling is more suitable than a sprayed acoustic tile ceiling in hospitals, because it gives access to the electrical and mechanical equipment above it providing a safe environment

and it is easier to clean (1982). The electronic instruments found in hospital operating rooms, and laboratories can threaten personal safety, because of the electrostatic charges. This can be prevented by using conductive ceramic tile, which is made from special compositions or by methods that result in specific properties of electrical conductivity, while retaining other physical properties of ceramic tiles (Zelinsky, 1995) (Figure B.39).

Airports are the areas that hundreds of people arriving and leaving, with heavy load and baggages. That's why the flooring material should be high abrasion resistant, and should have a high mechanical load-bearing capacity. Because of some technical problems, or weather conditions, sometimes people spend a lot of time waiting for the flights. This is a reason to create environmentally friendly and hygienic atmospheres while designing airports. It is important to select a material that is easy to clean and stain resistant to provide this effect. As there are a lot of people walking around, usually in a hurry, the flooring material must be slip resistant to prevent any hazards or falls. Ceramic tiles are the ideal materials having all these characteristics in designing an airport (Figure B.40).

The materials selected for the interior or surround of the **pools**, should have both some physical and chemical characteristics. Because of these requirements, ceramic tiles are the most suitable choices for swimming pools. It is resistant to freezing, acids, alkalis and pool chemicals, abrasion and wear, ultraviolet rays, thermal shocks and temperature variations. The low rate of water absorption of ceramic tiles, provides them to be maintenance free and stay clean for a long time. By this way, no micro-organisms are produced, and hygiene is provided, because

no tiles can become covered with moss or other bacteria. For outdoor pools, another characteristic is that ceramic tiles will not change their color, and loose the shiny look, after the long exposure to sunlight. Also Baykal states that, at the shallow parts, the stairs, and the surround, the slip resistance property of tile is of prime importance. For the pool surround, it is also important that ceramic tiles do not become too warm to walk on (1996) (Figure B.41).

There are millions of people working in **offices** worldwide. Some of these offices are study areas attached to a private residence, and the others are parts of a large complex. In both types, an office is a place where people spent nearly half of a day. Inspite of all these hours spent behind a desk, moving papers, typing and telephoning, the office building and the office interior has become the interest of the architect. Phillips adds that, today's companies provided créches for the children of working parents, exercise rooms with swimming pools, restaurants, and facilities where office-based associations, groups and clubs could meet (1991b). It needs to be careful while choosing materials in designing a place having such complex functions. Because of spending a lot of time in the same place, the area should be environmentally friendly. Brandt states that, chemical vapours from office copiers and other equipment, smoke of cigarettes, and bacteria growth in HVAC ductwork or damp areas, can cause chemical and bacteriological situations that may seriously affect employee health over long term. The proper cleaning and maintenance of the offices can impose the situation (1992). Because of the frequent use and high daily wear and tear, the material must be durable, have high abrasion resistance and load-bearing capacity. Determination of material's fire resistance properties and slip resistance are also important factors. Keeping all

these concerns in mind, it is the right decision to choose ceramic tiles. Also their electrical conductivity property can be useful in computer rooms in order to prevent any possibilities of fire, that's because of short circuits or other electrical problems (Figure B.42).

Parks are important elements of our urban environment and landscape. The functions of a park should include not only providing people fresh air and nature, but also a place they can meet and enjoy eachother (Phillips, 1996). As it is a place for relaxing and recreation, by creating positive feelings, parks should be beautiful, friendly, have excellent maintenance, and the materials used must be durable against frequent use. Today, parks in the city have to be designed as well as any building. Parks are for all people regardless of income, race, sex, and age, because they are open to anyone who wishes to use them. That's why, in order to serve for all these different kinds of people for a long time, selecting paving materials, while designing a park, is very important. They should be not only durable against all kinds of whether conditions, deep abrasion, heavy loads, daily wear and tear, but also easy to clean and stain resistance. Ceramic tiles, having all these characteristics, can also create a sense of warmth, scale, beauty and interest, that is hard to find in other materials. Installation of ceramic tiles is becoming increasingly popular for walkways, sitting areas, and public spaces. Interesting patterns can be created by mixing different colors, shapes and textures, to delineate spaces (Figure B.43).

Shopping malls are not only retail outlets anymore, but also gathering places for leisure activities and social interaction. These complexes implicate an increasing

number of services including boutiques, restaurants, cinemas, crèches and so on. This increased number of functions make shopping malls visited by a great number of people everyday. For this reason, the design of a mall or plaza must consider the type, size, scale, location and materials properly. According to Rubenstein, the choice of materials is important not only for design continuity, but also for both durability and ease of maintenance. Scale, pattern, color, and texture are form characteristics related to the design of the flooring concept for a mall. The paving pattern gives order to the overall design of a mall (1992). The flooring material chosen for a shopping mall must have some physical properties, as well as aesthetic requirements. It should have a high mechanical load-bearing capacity, durable, abrasion resistant, easy to clean and hygienic, and resistant to high foot traffic. Ceramic tiles offer all these advantages with a great variety of textures and colors, available in many sizes and shapes (Figure B.44).

There is no field of **industrial application** for which ceramics would be unsuitable. Industrial buildings are the areas where large number of production and heavy items take place. According to the guide of *Ceramics for Industrial Applications*, whether waterworks or factories, production building or warehouse: ceramics are used for construction and design purposes. The aesthetic quality of the material, having an increasing role in the projects, designed to render the working environment more human (1990). It is a material perfectly capable of resisting even the most comprehensive requirements of industrial construction. It doesn't matter designing breweries or sausage factories, elegant facades or floors; the selected material should have maximum anti-slip properties, hygienic, and have an elegant aesthetic design, combined with extreme durability and ability to create a

bright and friendly athmosphere. It is also important to keep in mind that, having resistance against chemicals, deep abrasion, heavy mechanical loads, thermal shocks and temperature variations, and water absorption, are other factors which make ceramic tiles be the best choice for industrial applications (Figure B.45).

5.2. Checklists

These checklists are prepared in order to be useful in choosing the right tile for the right application. As there are various kinds of materials for construction and decoration, ceramic tiles also have a lot of classifications in itself. Each type of tile can be suitable for different areas, as the rate of their resistance properties differ for each type. Because of that reason, it is important know which resistances are required for which area, in order to provide proper and long-lasting installations. That's why, it is important to take care of the guides available to the designer for the uses of different kinds of tile.

This guide includes two checklists, one for residential areas (Table 5.1), and the other is for public areas (Table 5.2). In each checklist, the areas explained in parts 5.1.1 and 5.1.2, and the resistance properties of ceramic tiles are listed. There are three categories for each characteristic, which are Applicable Feature, Useful Feature, and Necessary Feature. Applicable Feature, which is symbolised as one black box, means that, this characteristic is not so much important for that specific area. It is optional to consider this characteristic for that case. Useful Feature, which is symbolised as two black boxes, means that, it will be useful to choose a tile having that characteristic in designing that specific area. Necessary Feature,

which is symbolised as three black boxes, means that, it has so much importance to select a tile having that characteristic for that specific area.

For example, when designing an entryway, it can be seen in Table 5.1 that the tile that is going to be chosen should have the properties of cleanliness and hygiene, abrasion and wear resistance, durability and long service life the most. On the other hand, it will be useful to consider slip resistance, water absorption and moisture resistance for that area. Also mechanical load-bearing capacity, resistance to chemicals, and frost resistance can be taken into account, but not so much necessary.

After identifying which requirements must be considered in the project, the next step is checking the tiles' test ratings. Every firm apply these tests to each type of their tiles, if the resistance properties of the product is suitable for the required standards, its production begins. The European Standards (CEN), developed by the European Committee for Standardisation, has taken as the base for the work being done on unifying world standards. A committee of the International Standards Organisation (ISO), made up of the most important tile-manufacturing countries including United States, Italy, Spain, Brazil, and Germany, have their unified international standards. Currently in the United States, the American National Standards Institute (ANSI), classifies tiles in three main groups based on their surface finish. ANSI tests glazed, unglazed, and special purpose tiles by the American Society for Testing Materials (ASTM) test procedures, giving the designer realistic guidelines for on-site performance comparisons ("Ceramic Tile of

Italy", 1989). The standards and requirements for characteristics of ceramic tiles are mentioned in Table 5.3.

The results taken from these tests are pointed out in brochures of each tile because each type of tiles' physical and mechanical characteristics are different. By that way, the properties and the rate of resistances against specific stresses of that tile can be learned. These information will be useful while finding the right tile for the right application, by also using the checklists. After the necessary requirements of the tile suitable for the project are identified from the checklists, then it is time to look at the brochures of the tiles available in the market. By comparing these requirements of the tiles with eachother, one can find the most suitable tile for that project.

Table 5.1. Checklist For Residential Areas In Choosing Ceramic Tiles

	Mechanical Load-bearing Capacity	Resist. to Chemicals Acids & Alkalis	Resist. to Thermal Shock	Resist. to Temp Heat & Fire	Color Permenance	Frost Resistance
Entryways	■	■				■
Halls						
Indoor Staircases	■	■		■ ■		
Outdoor Staircases	■	■ ■	■ ■ ■	■ ■ ■	■ ■	■ ■ ■
Living Room	■			■ ■		
Dining Room	■					
Kitchen	■	■ ■ ■	■	■ ■ ■		
Bathroom		■ ■ ■	■	■ ■ ■		
Bedroom						
Patios	■	■ ■	■ ■ ■	■ ■ ■	■ ■	■ ■ ■

■ Applicable Feature ■ ■ Useful Feature ■ ■

Table 5.2. Checklist For Public Areas In Choosing Ceramic Tiles

	Mechanical Load-bearing Capacity	Resist. to Chem. Acids & Alkalis	Resist. to Thermal Shock	Rtrical Hductivity	Color Permenance	Frost Resistance
Subways & Statlons	■ ■ ■	■ ■ ■	■ ■ ■			■ ■ ■
Restaurants & Bars	■ ■	■ ■ ■				
Hotels	■ ■ ■					
Shopping Malls & Plazas	■ ■ ■					
Hospltals & Medical Centers	■ ■	■ ■ ■		■ ■		
Swimming Pools		■ ■ ■	■ ■ ■		■ ■	■ ■ ■
Office Buildings	■			■ ■		
Parks & Walkways	■ ■ ■	■ ■	■ ■ ■		■ ■	■ ■ ■
Alrports	■ ■ ■					
Industrial Buildings	■ ■ ■	■ ■ ■	■ ■	■ ■		■ ■

■ Applicable Feature ■ ■ Useful Feature

Table 5.3. Standards and Requirements for Characteristics of Ceramic Tile

CHARACTERISTICS	STANDARDS	REQUIREMENTS
Mechanical Load-bearing Capacity	ASTM C 648-84 ISO 10545-4 ISO 10545-5 TS EN 100	> 27 N/mm
Resistance to Chemicals	ASTM C 650-83 ASTM C 515-95 ISO 10545-13 TS EN 106 TS EN 122	Required
Resistance to Thermal Shock	ASTM C 484-86 ISO 10545-9 TS EN 104	Required
Resistance to Temp. Var. Heat & Fire (From +20 C to +100 C)	ISO 10545-8 TS EN 103	< 9x10 /C
Cleanliness & Hygiene	ISO 10545-14	Required
Slip Resistance	ASTM C 1028-89	>R9, >A*
Abrasion & Wear Resistance	ASTM C 501-84 ASTM C 1027-84 ASTM C 1243-93 ISO 10545-6 ISO 10545-7 ISO 10545-11 TS EN 101 TS EN 102 TS EN 105	> 5 Mohs

Table 5.3. (Continued from page 102)

	TS EN 154	
Water Absorption & Moisture Resistance	ISO 10545-3 ISO 10545-10 TS EN 99 TS EN 121 TS EN 155 TS EN 159 TS EN 176-177-178 TS EN 186-187-188 TS 202	< 3.0%
Electrical Conductivity	ASTM C 483-95	Required
Color Permenance	ASTM C 609-90	Required
Frost Resistance	ASTM C 1026-87 ISO 10545-12 TS EN 202	No alteration with 50 cycles

*...R9: Anti-slip for commercial use	COF (dry and unpolished): 0.4 - 0.75 COF (wet): 0.2 - 0.4
A: Anti-slip for dry floors	COF (non-textured): > 0.75 COF (textured): > 0.75
AB: Anti-slip for wet rooms	COF (non-textured): > 0.75 COF (textured): 0.4 - 0.75

(For the explanations of standards, see Appendix A)

6. CONCLUSION

When it is asked to people about ceramics, the answers are usually related with mugs or plates. But, ceramics have a deeper meaning. Its definition can be classified according to three types of criteria. First one is Historical ceramics, which have no production today. That's why they also have an artistic value, because they are the only few examples of a long history. Ceramics are the only materials that can stand out for ages, carrying the historical knowledge till today. They are still the sources of inspiration of some designers, who wants to create an ancient look in the environment. Second one is Artistic ceramics, which are art works created in the hands of a potter or a ceramist. Their aesthetic value is more than functional. The possibilities in the ceramic technology that have appeared due to new developments have not created a gap between the ordinary potter that shapes and fires the clay, and the artist who adds an artistic dimension to his work contrary to other forms of art. The basic material for the artist of today, and yesterday's unknown potter is certainly ceramics. The third one is Industrial ceramics, which also have an artistic value. While their mechanical and physical properties make them to be functional, their variety in size, shape, color, pattern and texture, make ceramic tiles to be visually attractive. This type of ceramics is the one that has an important role in architecture and design process, which forms the main scope of the thesis. Making an architectural design, is not only drawing plans or sections. To obtain a perfect design, some other points, which are

accepted to have least importance, must be considered like material selection. Choosing the correct material has so much importance in creating aesthetically pleasing and long-lasting installations. And ceramics have the ability to create any kind of effect on any environment, by endless design possibilities and functional choices.

In this thesis, first it is studied that ceramic is a classic, valid for all ages and all cultures. Today, there are modern designs and developed techniques besides all these original patterns which are so many centuries old. The reasons which provide ceramics last for such a long time, are its mechanical and physical properties, which are the important points in the scope of the thesis. It is explained that, these properties are the main factors affecting the proper selection of ceramic tiles.

In spite of the variety of different covering materials that new technology had created, ceramic provides its throne because it is smart and practical. Ceramic tiles help to emphasise architecture and integrate color schemes. They may be used in the same applications as any other element of interior design. These applications have no boundaries for ceramic tiles, appearing in commercial as well as residential projects, which are also mentioned in the thesis. It can be used in the entrance of a house, or on the exteriors. It can take place in the bathroom or kitchen, living room and corridors, by creating impressive combinations. Although it can be selected for all areas, can also be applied to small areas as a decorative element.

Another important part of the thesis is expressing the design phrase of ceramic tile installation. Design elements, such as color, pattern, size and shape, and texture, form up the main scope of the design, by creating endless design possibilities. These possibilities have great effects on the environment, as ceramic tiles are materials that are environmentally friendly, also can create warm and comfortable atmospheres. Lots of architects and interior designers prefer to choose ceramic tiles in their projects because of all the advantages they provide to the design. But, ceramic material can be successful in architecture, with a team work, and a time period. Design, selection of the material, and installation, are like the links of a chain. A defect occuring in one of them, will completely affect the result, and prevent to create a successful project.

The future of ceramic tiles is bright, because both the commercial and residential markets are looking for stylish, easily maintained surfaces, that are not only carefree and functional, but also reflective of personal and corporate values. As ceramic tiles continue to occupy larger segments of the home and commercial market, the industry continues to search for improvements and develop new processes that will bring the market better products.

There are some other aspects that need further investigation. First of all, only the most common areas of use of ceramic tiles are investigated, but there are so many others. Another aspect is that, while pointing out the comments of architects, interior designers and ceramists, a questionaire or some interviews could have been made, in order to get more reliable results. Concerning these facts, the study can be progressed to a larger extend.

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APPENDIX A

EXPLANATIONS OF STANDARDS

AMERICAN SOCIETY FOR TESTING MATERIALS (ASTM):

1996 ANNUAL BOOK OF ASTM STANDARDS

C 483-95 Standard Test Method for Electrical Resistance of Conductive Ceramic Tile

This method covers the determination of the electrical resistance of conductive ceramic tile prior to installation. This test method provides a means for determining whether conductive ceramic tile meets electrical resistance requirements to prevent the accumulation of dangerous electrostatic charges, which, in the presence of flammable gases, may cause possible explosions through spark discharges. Such electrical resistance requirements are specifically called for floors of other rooms where flammable agents are stored and handled.

C 484-86 Standard Test Method for Thermal Shock Resistance of Glazed Ceramic Tile

This test method covers the determination of the resistance of glazed ceramic tile to thermal shock.

C 501-84 Standard Test Method for Relative Resistance to Wear of Unglazed Ceramic Tile by The Taber Abraser

This test method covers the establishment of an abrasive wear index by determination of the loss of weight resulting from abrasion of unglazed ceramic tile.

C 609-90 Standard Test Method for Measurement of Small Color Differences Between Ceramic Wall and Floor Tile

This test method covers the measurement of a visually small color difference between two pieces of solid-colored, glazed or unglazed ceramic tile, using any photoelectric instrument that meets the requirements specified in the test method. The amount and the direction of the color difference are expressed numerically, with sufficient accuracy for use in product specification. This test method should not be used for determining small color differences between tile that have a multi-colored speckled, or textured surface, because the results may not be valid. Color difference between specimens found to be metameters, by visual examination, can be accurately evaluated by spectrophotometric measurement only.

C 648-84 Standard Test Method for Breaking Strength of Ceramic Tile

This test method covers the determination of the breaking strength of glazed ceramic wall tile, ceramic mosaic tile, quarry tile, and paver tile having a facial area of at least 6.4 square cm. It provides means for establishing whether or not a lot of ceramic tile meets the strength requirements which may appear in tile specifications. Tile strength is the force (or newtons), as read from the pressure gage, necessary to cause the tile to break.

C 650-83 Standard Test Method for Resistance of Ceramic Tile to Chemical Substrates

This method covers a procedure for determining whether, and to what degree, ceramic tiles are affected by prolonged exposure to chemical substrates. It is intended for testing ceramic tile that are to be used for food counters, lavatories,

and similar residential, medical, and commercial installations, where they may come in contact with food, chemical and waste substances and for tile in areas where they may be exposed to contact with strong cleaning agents.

C 1026-87 Standard Test Method for Resistance of Ceramic Tile to Freeze-Thaw Cycling

This test method describes the procedures and equipment required to test either glazed or unglazed ceramic tile for resistance to repeated cycles of freezing and thawing. Ceramic tile of any size or shape may be tested by this test method. The test for resistance to freezing and thawing functions as a guide to the selection of ceramic tile suitable for outdoor service in geographic areas subjected to freezing. It can serve as a test method to verify compliance with specifications for ceramic tile, and provides a control test for determining the uniformity of tile being manufactured for exterior installations.

C 1027- 84 Standard Test Method for Determining Visible Abrasion Resistance of Glazed Ceramic Tile

This test method is designed to measure the resistance of glazed tile to visible surface abrasion. Certain irregular glazed surfaces may not be evaluated properly by this test method because of wear patterns.

C 1028-89 Standard Test Method for Determining The Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by The Horizontal Dynomometer Pull-Meter Method

This test method covers the measurement of static coefficient of friction of ceramic tile or other surfaces under both wet and dry conditions while utilising neolite heel assemblies. The Horizontal Dynomometer Pull-meter and heel assemblies are designed to determine the static coefficient of friction of tile and like materials. This measurement is believed to be one important factor relative to slip resistance. Other factors can affect slip resistance, such as degree of wear on the shoe and flooring material, presence of foreign material, such as water, oil and dirt, the length of human stride at the time of slip, type pf floor finish, and the physical and mental conditions of humans. Therefore this test method should be used for the purpose of developing a property of the flooring surface under laboratory conditions, and should not be used to determine slip resistance under field conditions unless those conditions are fully described. Because many variables may enter into the evaluation of slip resistance of a particular surface, this test method is designed to evaluate these surfaces under both laboratory and actual site installation conditions.

C 1243-93 Standard Test Method for Relative Resistance to Deep Abrasive Wear of Unglazed Ceramic Tile by Rotating Disc

This test method covers the deep abrasive wear by measuring the loss of volume resulting from abrasion of unglazed ceramic tile under given conditions by means of a rotating disc and the use of abrasive material. It provides the means to measure the potential resistance to wear of unglazed ceramic tile intended for floor

coverings. It does not consider physical appearance, but it is intended to measure durability.

1997 ANNUAL BOOK OF ASTM STANDARDS

C 1167- 96 Standard Specification for Clay Roof Tiles

This method covers clay tiles intended for use as roof covering where durability and appearance are required to provide a weather-resistant surface of specified design. Tiles are manufactured from clay, shale or similar naturally occurring earthy substances and subjected to heat treatment at elevated temperatures (firing). The heat treatment must develop a fired bond between the particulate constituents to provide the strength and durability requirements of this specification. Tiles are shaped during manufacture by moulding, pressing, or extrusion and it is permitted to use the shaping method to describe the tiles. Tiles are generally planar or undulating rectangular shapes available in a variety of cross-sectional profiles, shapes, sizes, surface textures, and colors. Three grades of tiles having various degrees of resistance to weathering are covered in this specification.

C 126- 96 Standard Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units

This method covers structural loadbearing facing tile and facing brick and other solid masonry units made from clay, shale, fireclay, or mixtures thereof, with or without the addition of grog and other mixtures having a finish consisting of a ceramic glaze fused to the body at above 655 degrees C, making them inseparable, excluding natural salt-glazed ware.

C 410- 60 Standard Specification for Industrial Floor Brick

This test method covers brick made from clay or shale or mixtures thereof and are suitable for surfacing industrial floors. Ceramic shapes known as quarry tile are not covered by this specification. Four types of industrial floor brick are covered:

Type T: For use where a high degree of resistance to thermal and mechanical shock is required but low absorption is not required.

Type H: For use where resistance to chemicals and thermal shock are service factors but low absorption is not required.

Type M: For use where low absorption is required. Brick of this type are normally characterised by limited mechanical (impact) shock resistance but are often highly resistant to abrasion.

Type L: For use where minimal absorption and a high degree of chemical resistance are required. Brick of this type are normally characterised by very limited thermal and limited mechanical (impact) shock resistance but are highly resistant to abrasion.

The factors of absorption and chemical resistance have been selected as the bases for the classification system.

C 1272- 95 Standard Specification for Heavy Vehicular Paving Brick

This test method covers brick intended for use as a paving material in areas with a high volume of heavy vehicular traffic. The units are designed for use in such places as streets, commercial driveways, and aircraft taxiways. Units are manufactured from clay, shale or similar naturally occurring earthy substances and subjected to heat treatment at elevated temperatures (firing). The heat treatment must develop a fired bond between the particulate constituents to provide the

strength and durability requirements of this specification. Physical requirements of this method are durability, resistance to freezing and thawing, abrasion resistance, skid resistance, resistance to chips and cracks.

C 902- 95 Standard Specification for Pedestrian and Light Traffic Paving Brick

This test method covers brick intended for use as paving material to support pedestrian and light vehicular traffic. The units are designed for use in such places as patios, walkways, floors, plazas and driveways. The units are not intended to support heavy vehicular traffic. Brick are manufactured from clay, shale or similar naturally occurring earthy substances and subjected to heat treatment at elevated temperatures (firing). The heat treatment must develop a fired bond between the particulate constituents to provide the strength and durability requirements of this specification. The brick are available in a variety of sizes, colors and shapes. They are available in three classes according to exposure environment, and three types according to type of traffic exposure. Light traffic paving brick are classified according to the severity of their use-environment are considered: Weather and Traffic.

1) Weather

Class SX: Brick intended for use where the brick may be frozen while saturated with water.

Class MX: Brick intended for exterior use where resistance to freezing is not a factor.

Class NX: Brick not intended for exterior use but which may be acceptable for interior use where protected from freezing when wet.

A surface coating may be applied to any class of brick of this standard when protected from freezing while wet. The function of the coating is to prevent penetration of dirt or liquids into the pores of the brick. Coatings should be applied only after complete drying of the paving.

2) Traffic

Type 1: Brick exposed to extensive abrasion, such as in driveways, and entranceways to public or commercial buildings.

Type 2: Brick exposed to intermediate traffic, such as floors in restaurants or stores and exterior walkways.

Type 3: Brick exposed to low traffic, such as floors or patios in single family homes.

Physical requirements of this test methods are; durability, resistance to freezing and thawing, and abrasion resistance.

C 67- 97 Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile

They cover procedures for the sampling and testing of brick and structural clay tile. Although not necessarily applicable to all types of units, tests include modulus of rupture, compressive strength, absorption, saturation coefficient, effect of freezing and thawing, efflorescence, initial rate of absorption, and determination of weight, size, warpage, length change, and void area.

C 212- 96 Standard Specification for Structural Clay Facing Tile

This specification covers structural clay load-bearing facing tile. Structural facing tiles are designed for use in interior and exterior unplastered walls and partitions of

buildings. Tile covered by this standard are manufactured from clay, shale or similar naturally occurring earthy substances and subjected to heat treatment at elevated temperatures (firing). The heat treatment must develop a fired bond between the particulate constituents to provide the strength and durability requirements of this specification. Two types of structural clay facing tile are covered:

Type FTX: Smooth-face tile suitable for general use in exposed exterior and interior masonry walls and partitions, and adapted for use where tile is low in absorption, easily cleaned, and resistant to staining are required, and where a high degree of mechanical perfection, narrow color range, and minimum variation in face dimensions are desired.

Type FTS: Smooth or rough texture face tile suitable for general use in exposed exterior and interior masonry walls and partitions, and adapted for use where tile of moderate absorption, moderate variation in face dimensions, and medium color range are permitted, and where minor defects in surface finish, including small handling chips are not objectionable. Two classes of structural clay facing tile are covered:

Standard: Tile suitable for general use in exterior or interior masonry walls and partitions, are designed to have superior resistance to impact and moisture transmission and to support greater lateral and compressive loads than standard tile construction.

C 34- 96 Standard Specifications for Structural Clay Load-Bearing Wall Tile

This test method covers structural clay load-bearing wall tile. Two grades of tile are covered:

Grade LBX: Suitable for general use in masonry construction and adapted for use in masonry exposed to weathering, provided they meet the durability requirements of Grade SW of Specification C 216.

Grade LB: Suitable for general use in masonry where not exposed masonry where protected with a facing of 76.2 mm. or more of stone, brick, terra cotta, or other masonry.

Tile covered by this standard are manufactured from clay, shale or similar naturally occurring earthy substances and subjected to heat treatment at elevated temperatures (firing). The heat treatment must develop a fired bond between the particulate constituents to provide the strength and durability requirements of this specification. Physical properties are water absorption and compressive strength.

C 56- 96 Standard Specifications for Structural Clay Non-Load-Bearing Tile

This covers structural clay non-load-bearing tile (partition, fire proofing, and furring). Tile covered by this standard are manufactured from clay, shale or similar naturally occurring earthy substances and subjected to heat treatment at elevated temperatures (firing). The heat treatment must develop a fired bond between the particulate constituents to provide the strength and durability requirements of this specification. Tile intended for use in fire proofing structural members shall be of such sizes and shapes that they can be erected to cover completely the exposed surfaces of the members.

C 530- 93 Standard Specifications for Structural Clay Non-Load-Bearing Screen Tile

This covers unglazed, structural clay non-load-bearing screen tile. Tile covered by this standard are manufactured from clay, shale or similar naturally occurring earthy substances and subjected to heat treatment at elevated temperatures (firing). The heat treatment must develop a fired bond between the particulate constituents to provide the strength and durability requirements of this specification. Three grades of screen tile, based on relative durability are covered:

Grade SE: Screen tile exhibiting a uniformly high resistant to disintegration by weathering or by freezing or thawing in the presence of moisture.

Grade ME: Screen tile exhibiting a moderate and somewhat nonuniform resistance to weathering. Grade ME tile exhibit good durability in areas of mild to moderate exposure but may not be adequate for severe exposures.

Grade NE: Screen tile for interior use (no exposure to rain or freezing).

Two types of screen tile, based on dimensional tolerances are covered as:

Type STX: Screen tile having degree of mechanical perfection and minimum size variation.

Type STA: Screen tile exhibiting characteristic architectural effects resulting from a larger degree of size variations than obtainable with type STX.

Physical properties are durability, and resistance to abrasion.

C 515- 95 Standard Specifications for Chemical Resistant Ceramic Tower Packings

This covers fired ceramic shapes forms from naturally occurring clays and from compounded bodies that are used as packing in tower installations. The physical

and chemical properties that affect quality of packing materials are covered in this specification. Properties that affect actual operational efficiency or characteristics of processing towers are not covered.

Physical requirements are crushing strength, water absorption, and acid resisting properties.

INTERNATIONAL STANDARDS ORGANISATION (ISO) CATALOGUE 1997

ISO 10545-3 Determination of Water Absorption, Apparent Porosity, Apparent Relative Density and Bulk Density

It specifies two methods for determining water absorption, apparent porosity, apparent relative density and bulk density of ceramic tiles. Impregnation is obtained by immersion into boiling water or by immersion under vacuum.

ISO 10545-4 Determination of Modulus Rupture and Breaking Strength

It defines a test method for determining the modulus rupture and breaking strength of all ceramic tiles. The principle is the determination of the breaking load, breaking strength and modulus rupture of a tile by applying a force at a definite rate to the centre of the tile, the point of application being in contact with the proper surface of the tile.

ISO 10545-5 Determination of Impact Resistance by Measurement of Coefficient of Restitution

It specifies a test method for determining the impact resistance of ceramic tiles by measuring the coefficient of restitution.

ISO 10545-6 Determination of Resistance to Deep Abrasion for Unglazed Tiles

It specifies a test method for determining the resistance to deep abrasion of all unglazed ceramic tiles used for floor covering.

ISO 10545-7 Determination of Resistance to Surface Abrasion for Glazed Tiles

It specifies a test method for determining the resistance to surface abrasion of all glazed ceramic tiles used for floor covering.

ISO 10545-8 Determination of Linear Thermal Expansion

It defines a test method for determining the coefficient of linear thermal expansion of ceramic tiles.

ISO 10545-9 Determination of Resistance to Thermal Shock

It defines a test method for determining the resistance to thermal shock of all ceramic tiles under normal conditions of use. Depending on the water absorption of the tiles, different procedures are used unless there is an agreement to the contrary.

ISO 10545-10 Determination of Moisture Expansion

It specifies a method for determining the moisture expansion of ceramic tiles. The majority of glazed and unglazed tiles have negligible natural moisture expansion that does not contribute to tiling problems when tiles are correctly fixed. However, with unsatisfactorily fixing practices, and in certain climatic conditions, natural moisture expansion may aggravate problems, especially when tiles are directly

fixed to inadequately aged concrete substrates. In these cases, a maximum limit of 0.06% moisture expansion is recommended when the test is used.

ISO 10545-11 Determination of Crazing Resistance for Glazed Tiles

It defines a test method for determining the crazing resistance of all glazed ceramic tiles except when the crazing is an inherent decorative feature of the product.

ISO 10545-12 Determination of Frost Resistance

It specifies a method for determining the frost resistance of all ceramic tiles intended for use in freezing conditions in the presence of water.

ISO 10545-13 Determination of Chemical Resistance

It specifies a test method for determining the chemical resistance of ceramic tiles at room temperature. The method is applicable for all types of ceramic tiles. Test solutions include household chemicals, swimming pool salts, acids and alkalis.

ISO 10545-14 Determination of Resistance to Stains

It defines a test method for determining the resistance to stains of the proper surface of ceramic tiles.

TURKISH STANDARDS (TS) AND EUROPEAN NORMS (EN)

TS EN 99 Method for Determination of Water Absorption

This standard defines a method of test for determining the water absorption of all ceramic tiles.

TS EN 100 Determination of Modulus of Rupture

This standard defines a method of test for determining the modulus of rupture of all ceramic tiles.

TS EN 101 Determination of Scratch Hardness of Surface According to Mohs

This standard defines a method of test for determining the scratch hardness of the surface of all ceramic tiles.

EN 102 Determination of Resistance to Deep Abrasion for Unglazed Tiles

This standard defines a method of test for determining the resistance to deep abrasion for unglazed tiles.

TS EN 103 Determination of Linear Thermal Expansion

This standard defines a method of test for determining the linear thermal expansion of all ceramic tiles.

TS EN 104 Determination of Resistance to Thermal Shock

This standard defines a method of test for determining the resistance to thermal shock of all ceramic tiles in normal conditions of use.

TS EN 105 Determination of Crazing Resistance of Glazed Tiles

This standard defines a method of test for determining the crazing resistance of all glazed ceramic tiles.

TS EN 106 Determination of Chemical Resistance of Unglazed Tiles

This standard defines a method of test for determining the chemical resistance of the proper surface of all unglazed ceramic tiles at room temperature.

TS EN 121 Extruded Ceramic Tiles with Low Water Absorption

This standard specifies the sizes, dimensional tolerances, mechanical, physical and chemical requirements, surface quality requirement and marking of extruded first quality ceramic tiles with low water absorption for interior and exterior use on both floor and walls, in all climatic conditions.

TS EN 122 Determination of Chemical Resistance of Glazed Tiles

This standard defines a method of test for determining the chemical resistance of the surface of the glaze of ceramic tiles at room temperature.

TS EN 154 Determination of Resistance to Surface Abrasion of Glazed Tiles

This standard defines a method of test for determining the resistance to surface abrasion of all glazed ceramic tiles for floor covering.

TS EN 155 Determination of Moisture Expansion Using Boiling Water for Unglazed Tiles

This standard defines a method of test for determining the moisture expansion of unglazed tiles having water absorption of 6%.

TS EN 159 Dust-Pressed Ceramic Tiles With Water Absorption (E>10%)

This standard specifies sizes, dimensional tolerances, mechanical, chemical and physical requirements, surface quality requirements, and marking of dust-pressed, first quality glazed tiles with a water absorption (E>10%), for use on both floor and wall coverings.

TS EN 176 Dust-Pressed Ceramic Tiles With A Low Water Absorption (E<3%)

This standard specifies sizes, dimensional tolerances, mechanical, chemical and physical requirements, surface quality requirements, and marking of dust-pressed, first quality glazed tiles with low water absorption (E<3%), for interior and exterior use both on walls and floors.

TS EN 177 Dust-Pressed Ceramic Tiles With A Water Absorption of 3%<E<6%

This standard specifies sizes, dimensional tolerances, mechanical, chemical and physical requirements, surface quality requirements, and marking of dust-pressed, first quality glazed tiles with water absorption (3%<E<6%), for interior and exterior use both on walls and floors.

TS EN 178 Dust-Pressed Ceramic Tiles With A Water Absorption of 6%<E<10%

This standard specifies sizes, dimensional tolerances, mechanical, chemical and physical requirements, surface quality requirements, and marking of dust-pressed, first quality glazed tiles with water absorption (6%<E<10%), for interior and exterior use both on walls and floors.

TS EN 186 Extruded Ceramic Tiles With A Water Absorption 3%<E<6%

This standard specifies sizes, dimensional tolerances, mechanical, chemical and physical requirements, surface quality requirements, and marking of extruded, first quality ceramic tiles with water absorption (3%<E<6%), for interior and exterior use both on walls and floors.

TS EN 187 Extruded Ceramic Tiles With A Water Absorption 6%<E<10%

This standard specifies sizes, dimensional tolerances, mechanical, chemical and physical requirements, surface quality requirements, and marking of extruded, first quality ceramic tiles with water absorption (6%<E<10%), for interior and exterior use both on walls and floors.

TS EN 188 Extruded Ceramic Tiles With A Water Absorption E<10%

This standard specifies sizes, dimensional tolerances, mechanical, chemical and physical requirements, surface quality requirements, and marking of extruded, first quality ceramic tiles with water absorption (E<10%), for interior and exterior use both on walls and floors.

TS 202 Glazed Ceramic Tiles (With High Absorption of Water)

This standard specifies the classification, properties, sampling, testing and marking of glazed ceramic tiles with high absorption of water.

TS EN 202 Determination of Frost Resistance

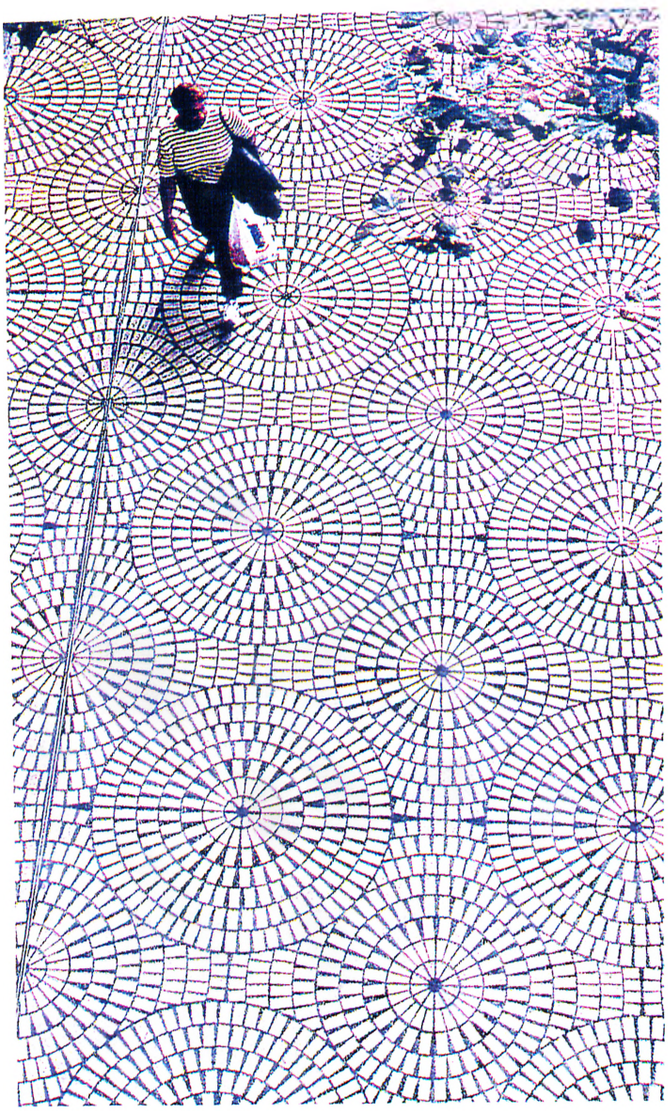
This standard defines a method of test for evaluating the frost resistance of all ceramic tiles intended for use in conditions of frost in the presence of water.

TS 2902 Ceramic Glazed Structural Clay Facing Tile, Facing Brick and Solid Masonry Units

This standard specifies the classification, properties, sampling, testing and marking of ceramic glazed structural clay facing tile, facing brick and solid masonry units.

APPENDIX B

FIGURES



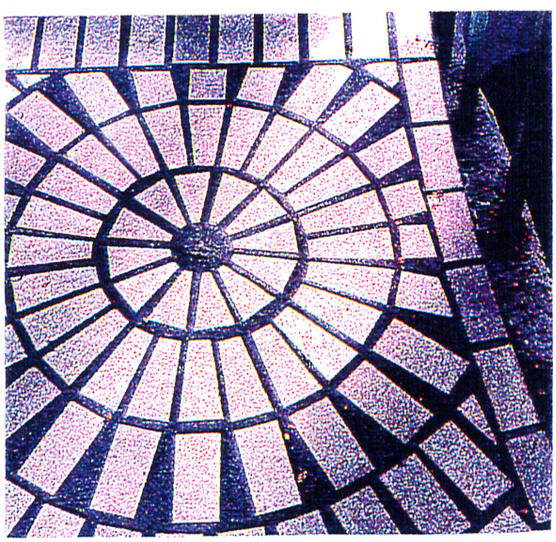


Figure B.1. Embarcadero Center

Figure B.2. Examples for Ceramic Tiles Used on Exterior Facades

Figure B.3. An Example for Ceramic Tiles Used on Exterior Pavements

Figure B.4. Examples for Ceramic Tiles Used on Roof Systems.

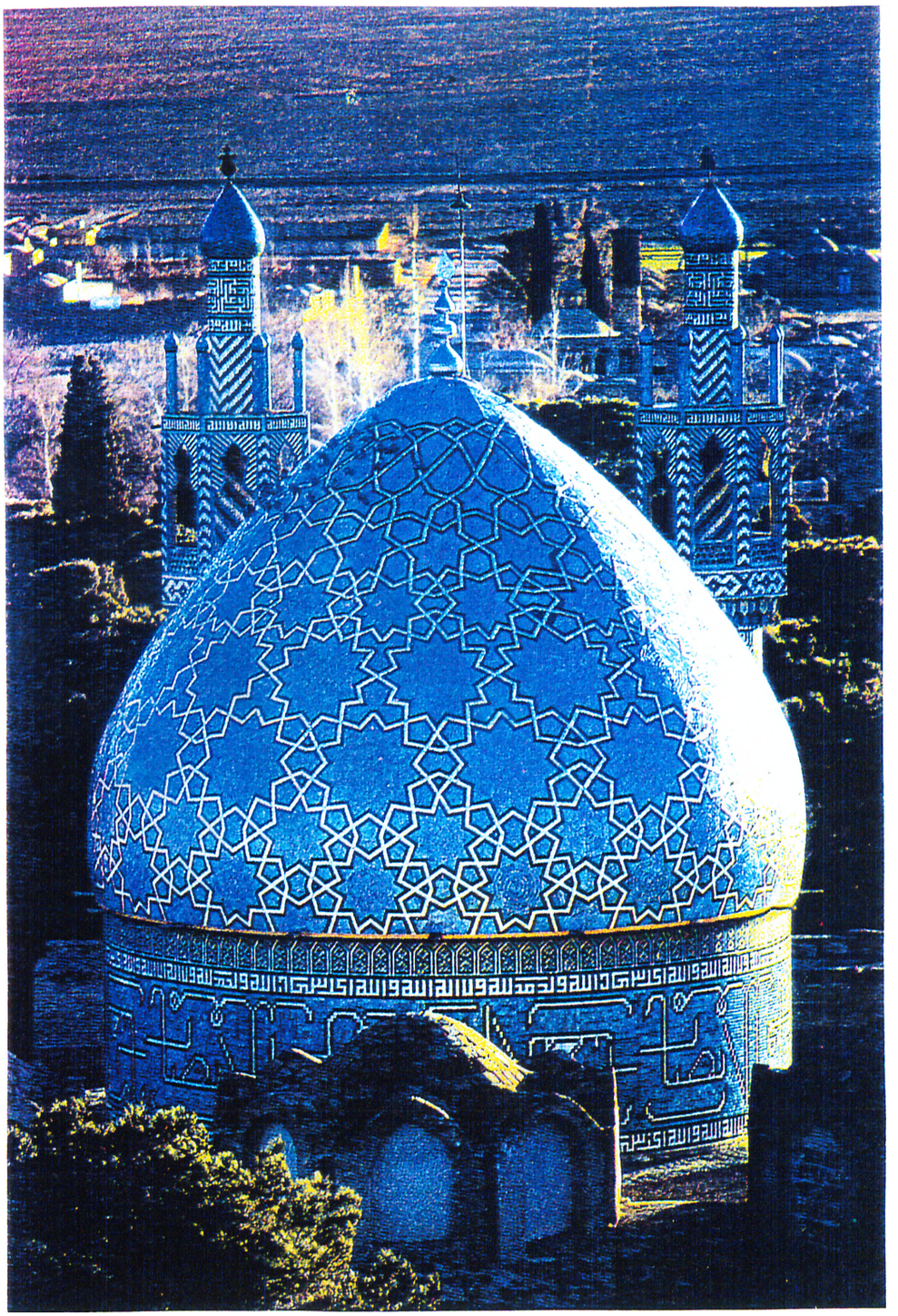


Figure B.5. An Example for Islamic Architectural Ceramics (Mahan-IRAN)

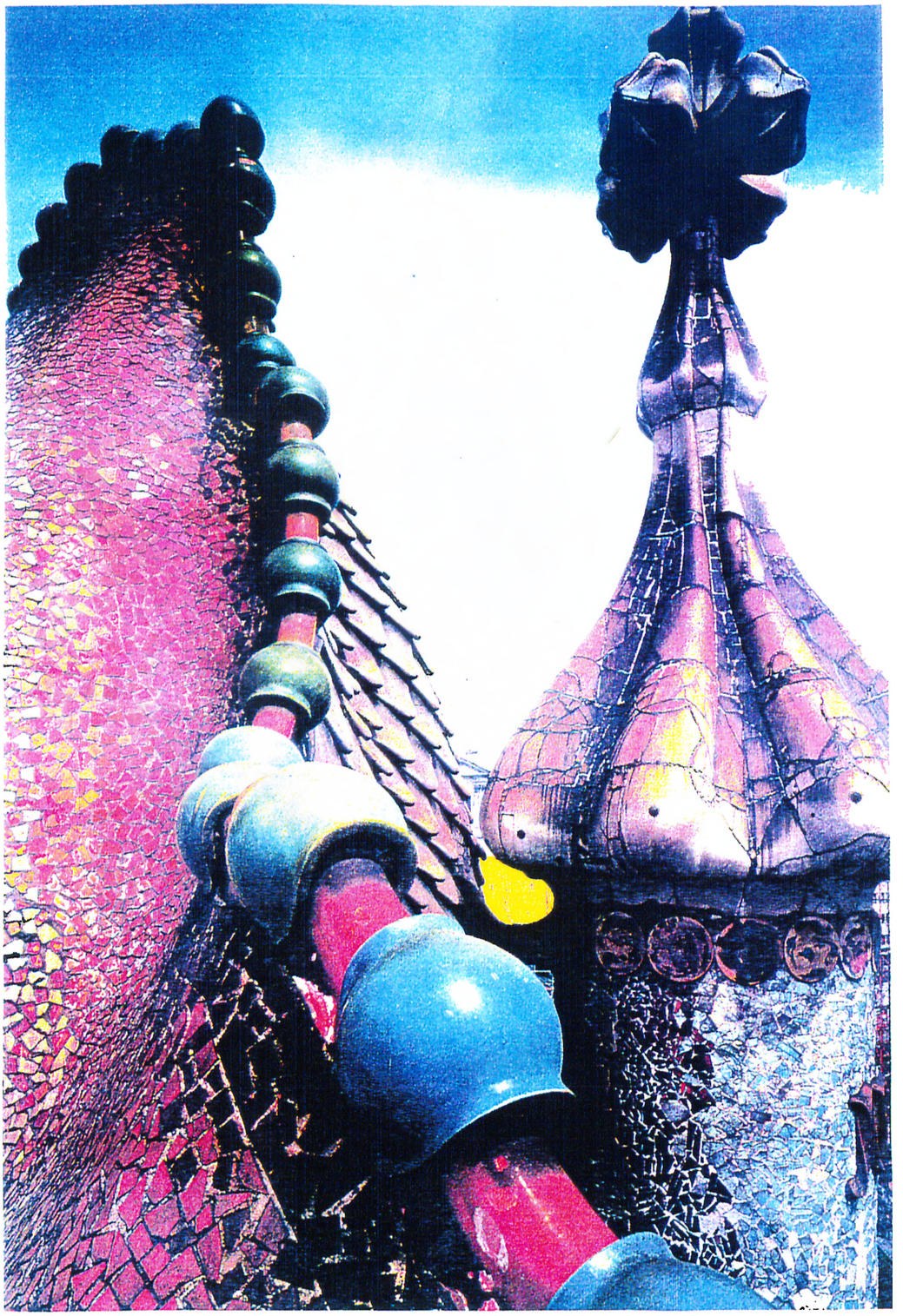


Figure B.6. Casa Battlo

Figure B.7. Güell Park

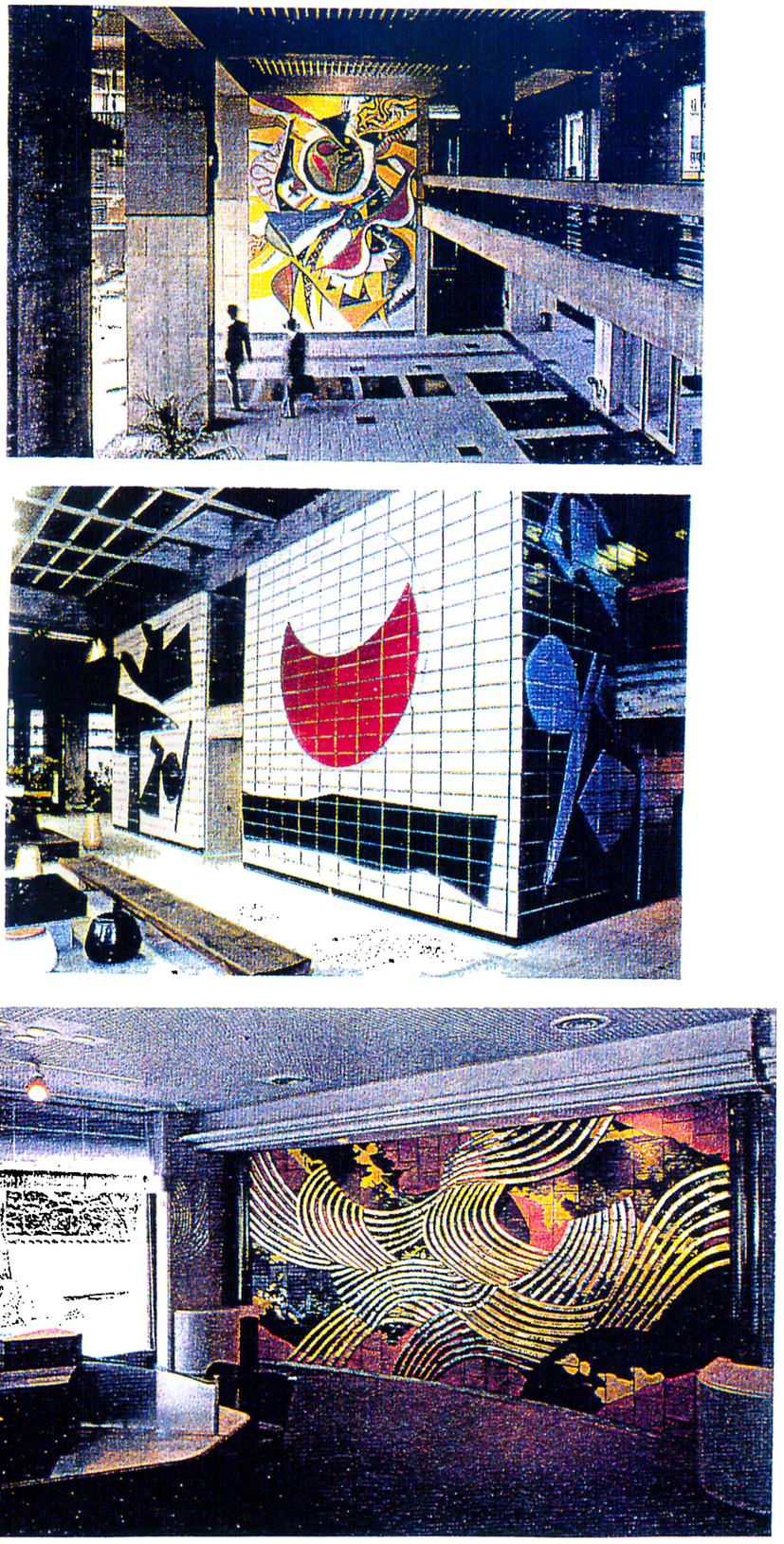


Figure B.8. Examples for Architectural Ceramics

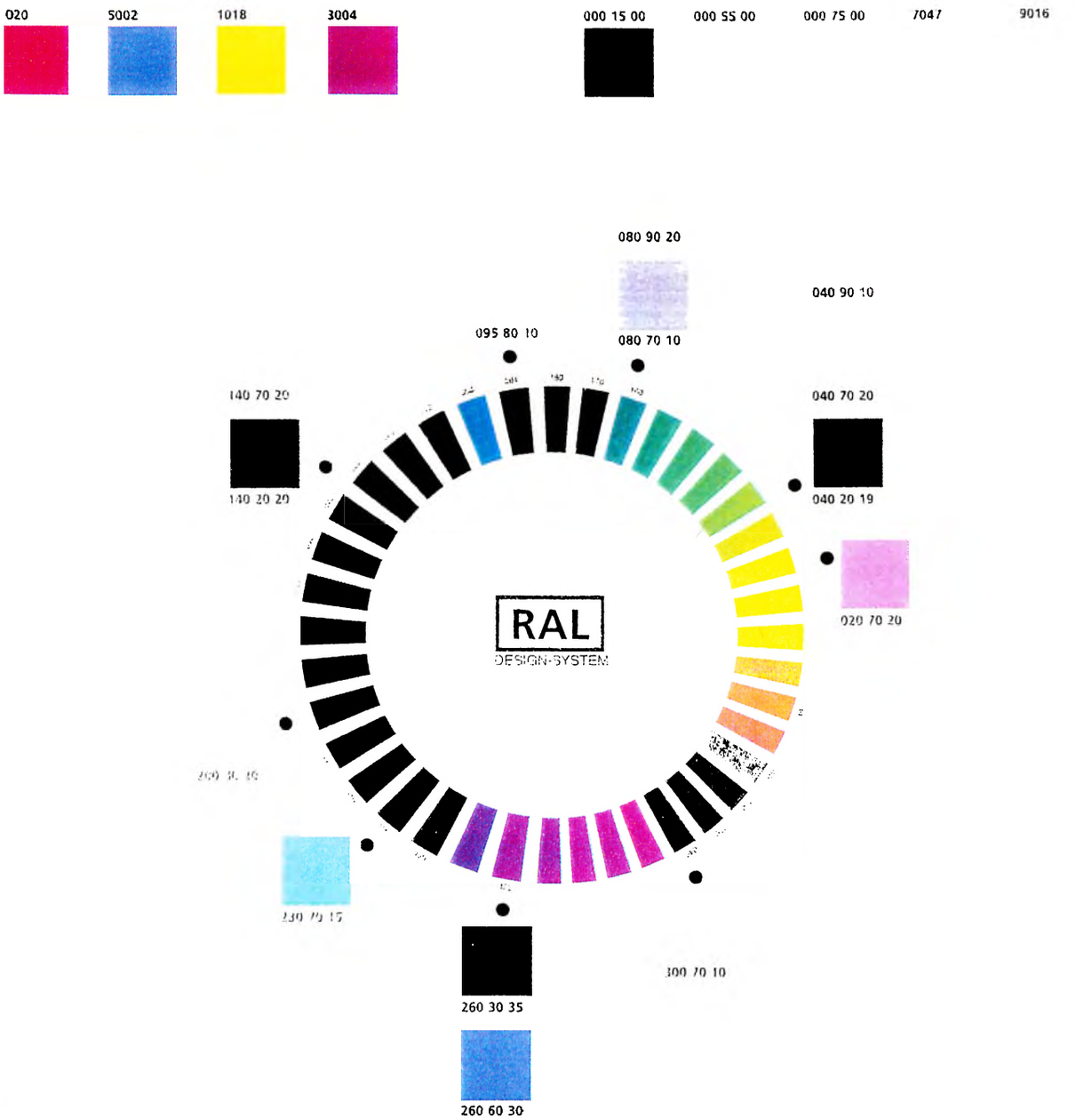


Figure B.9. RAL Color System

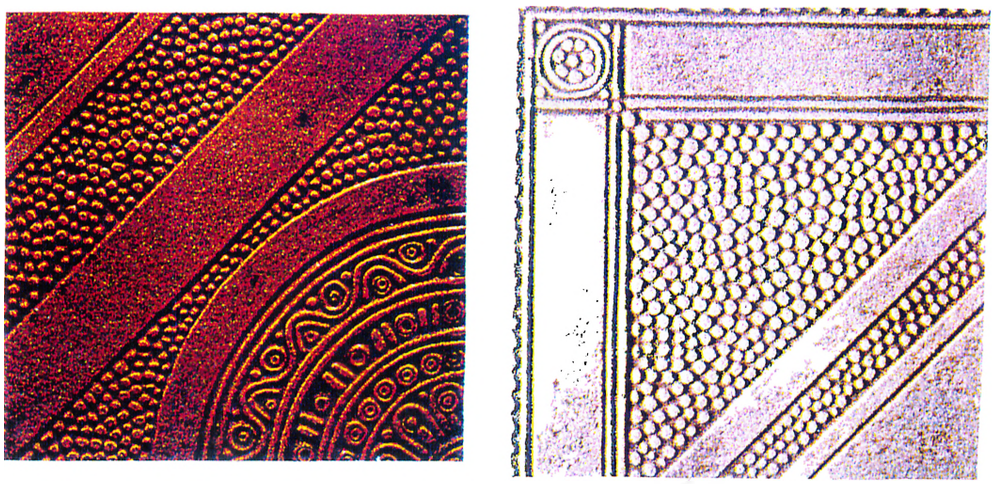


Figure B.10. Examples for Tactile Textures

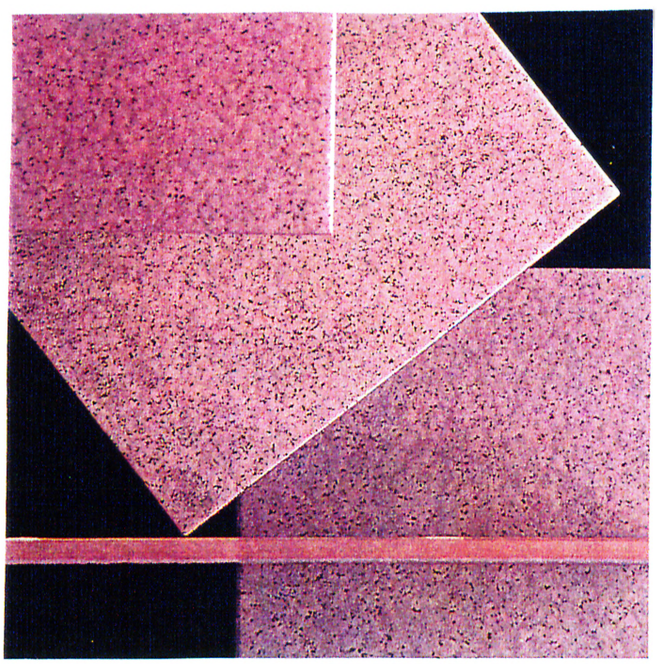


Figure B.11. Examples for Visual Textures

Figure B.12. St. Enoch Center

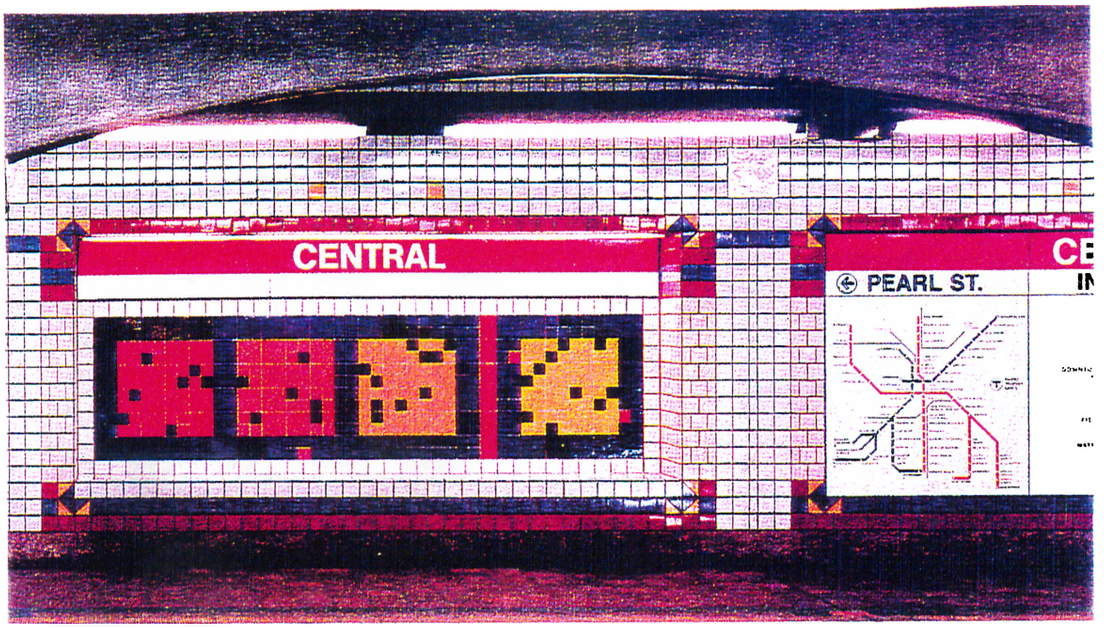


Figure B.13. Central Square Transit Station

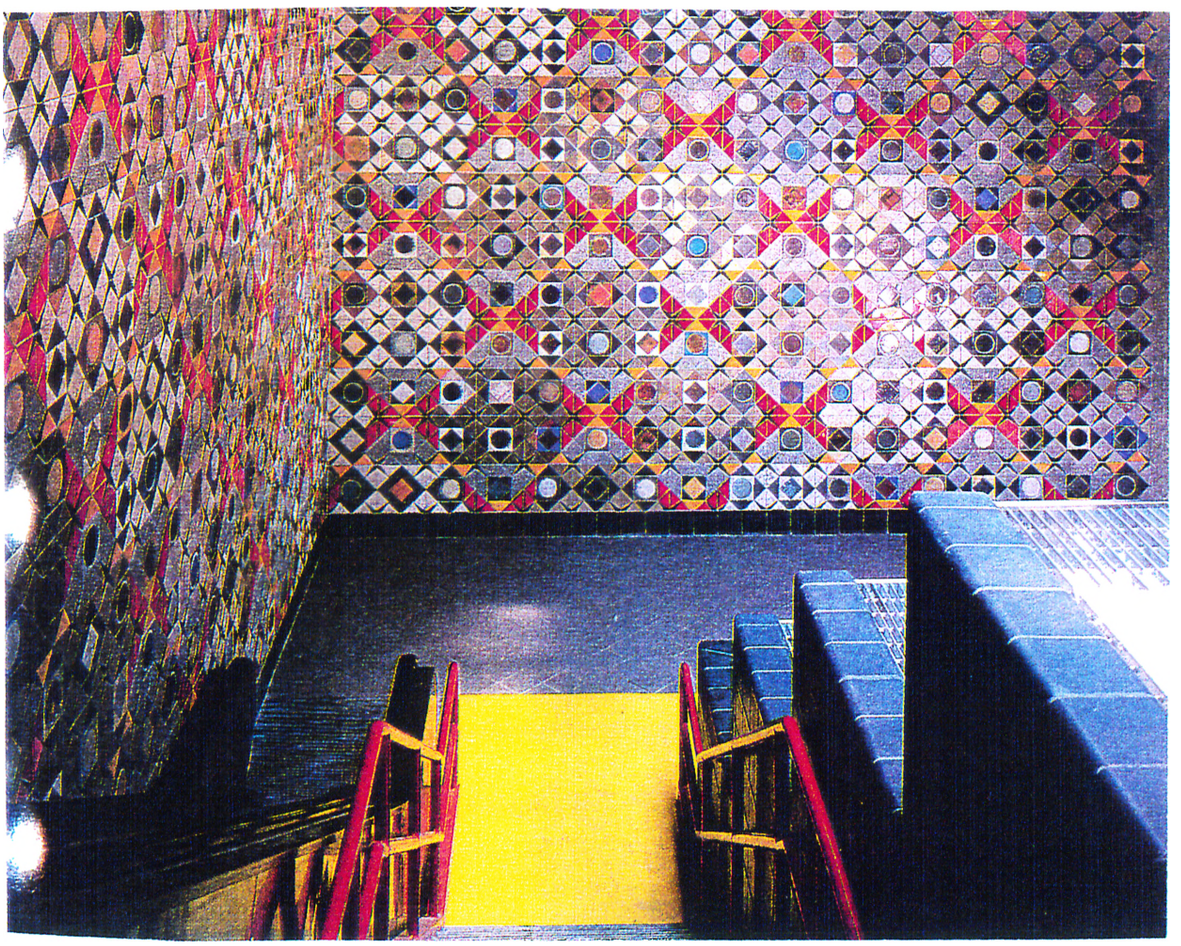


Figure B.14. Detroit People Mover Transit System.

Figure B.15. An Example for the Work of Architect Hundertwasser

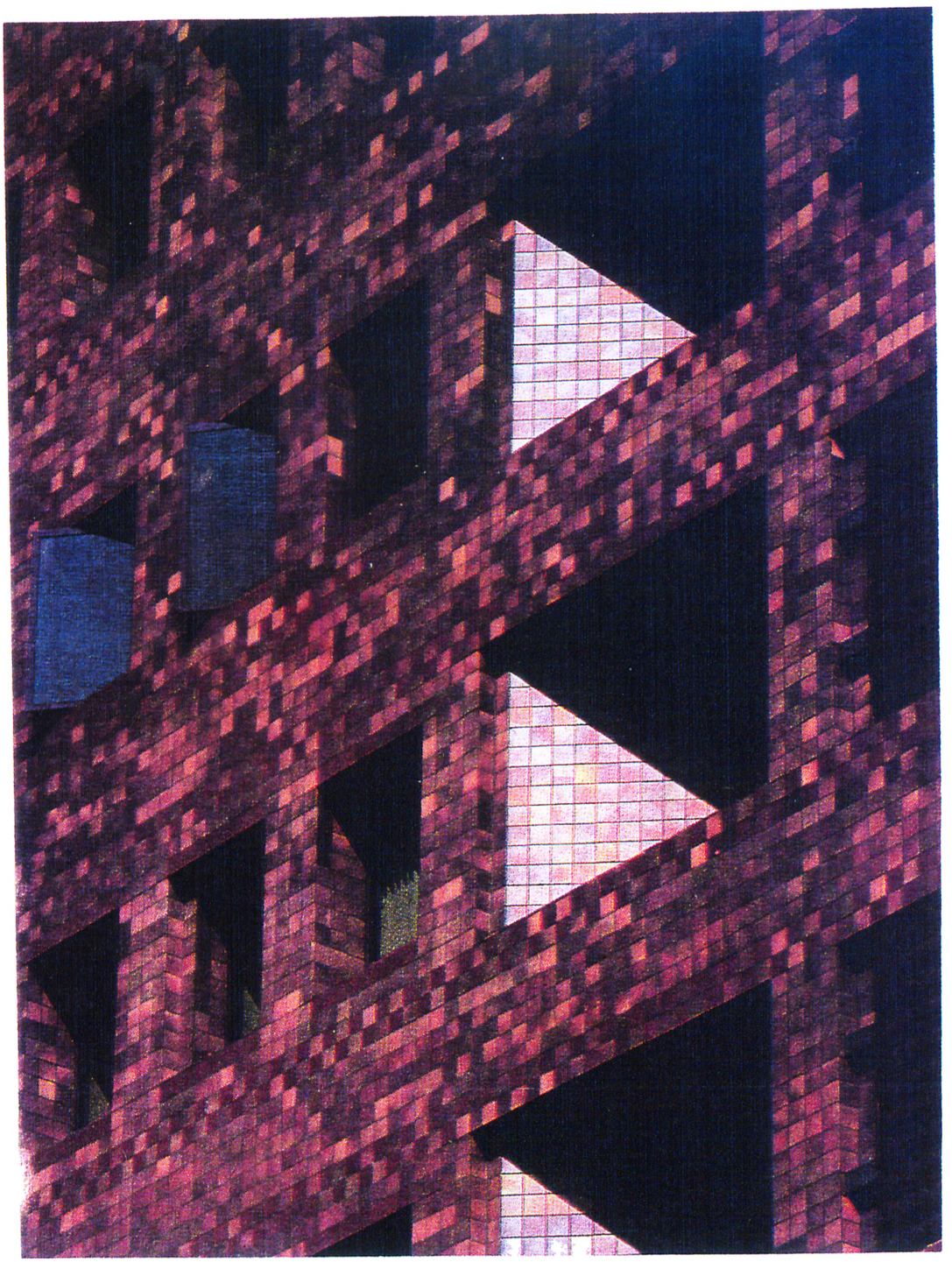


Figure B.16. Facade of a Building in Dallas.

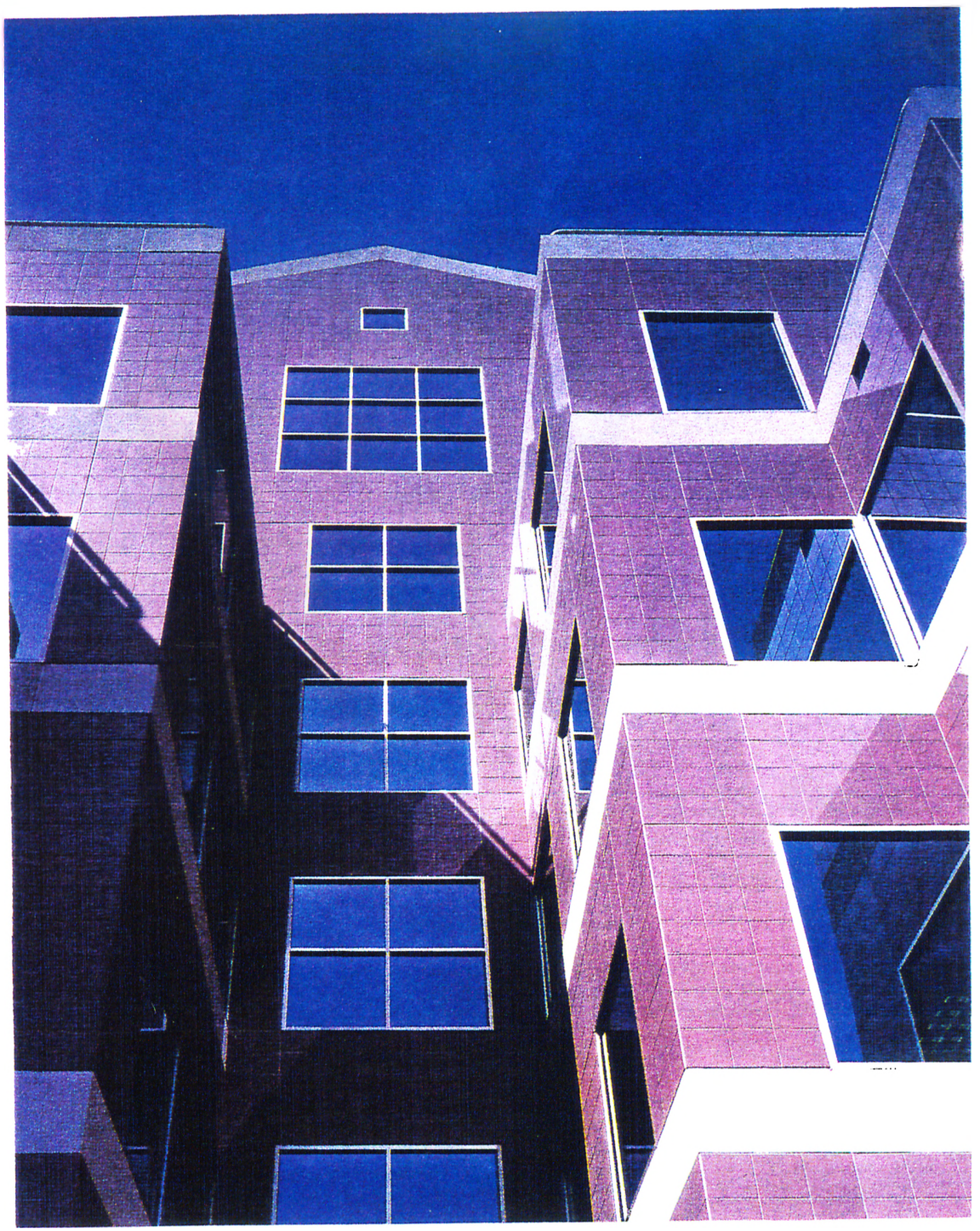


Figure B.17. California Medical Center

Figure B.18. Medical Exhibition and Marketing Center

Figure B.19. Shiseldo Health Club

Figure B.20. Trapper's Alley

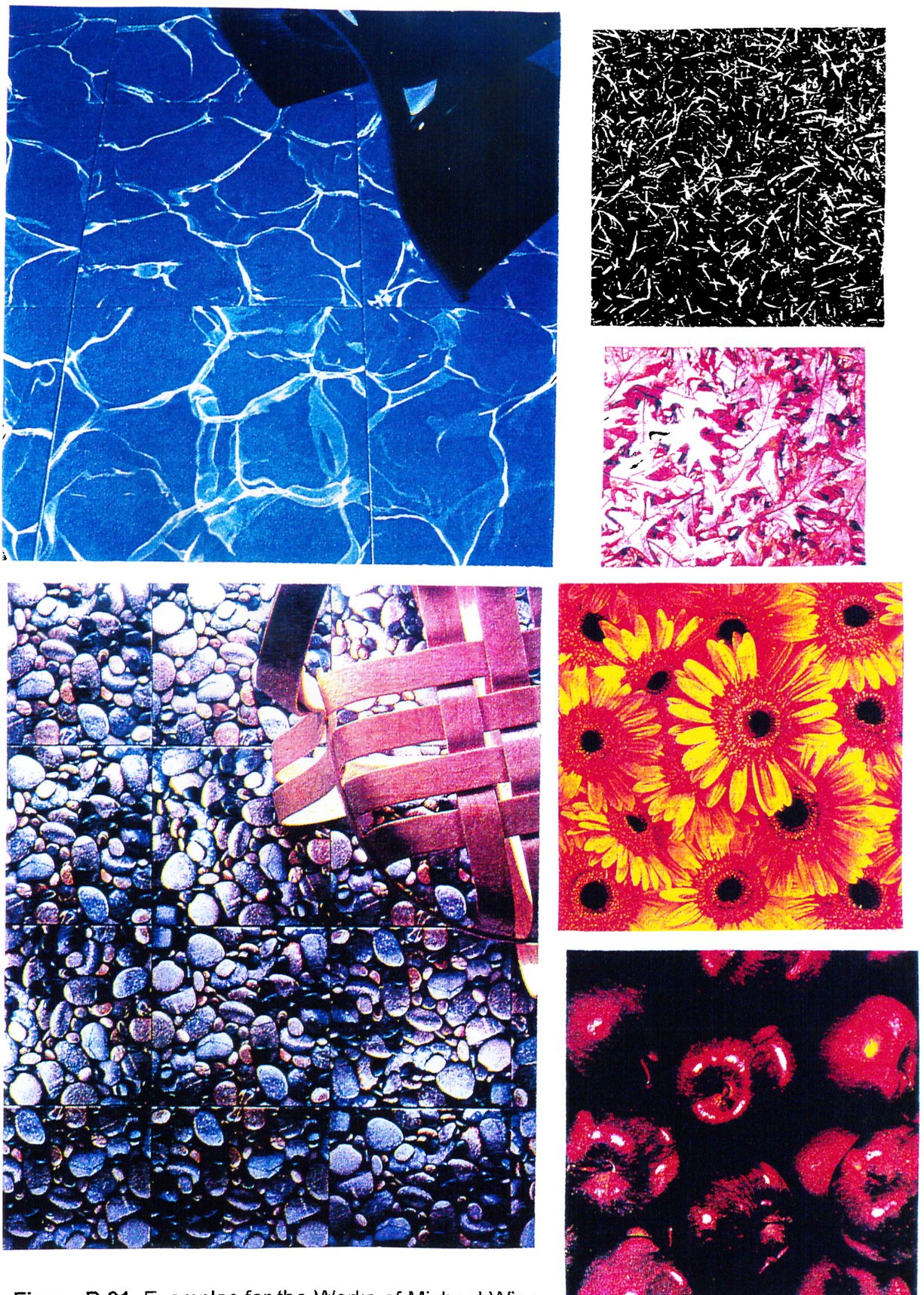


Figure B.21. Examples for the Works of Michael Wine.

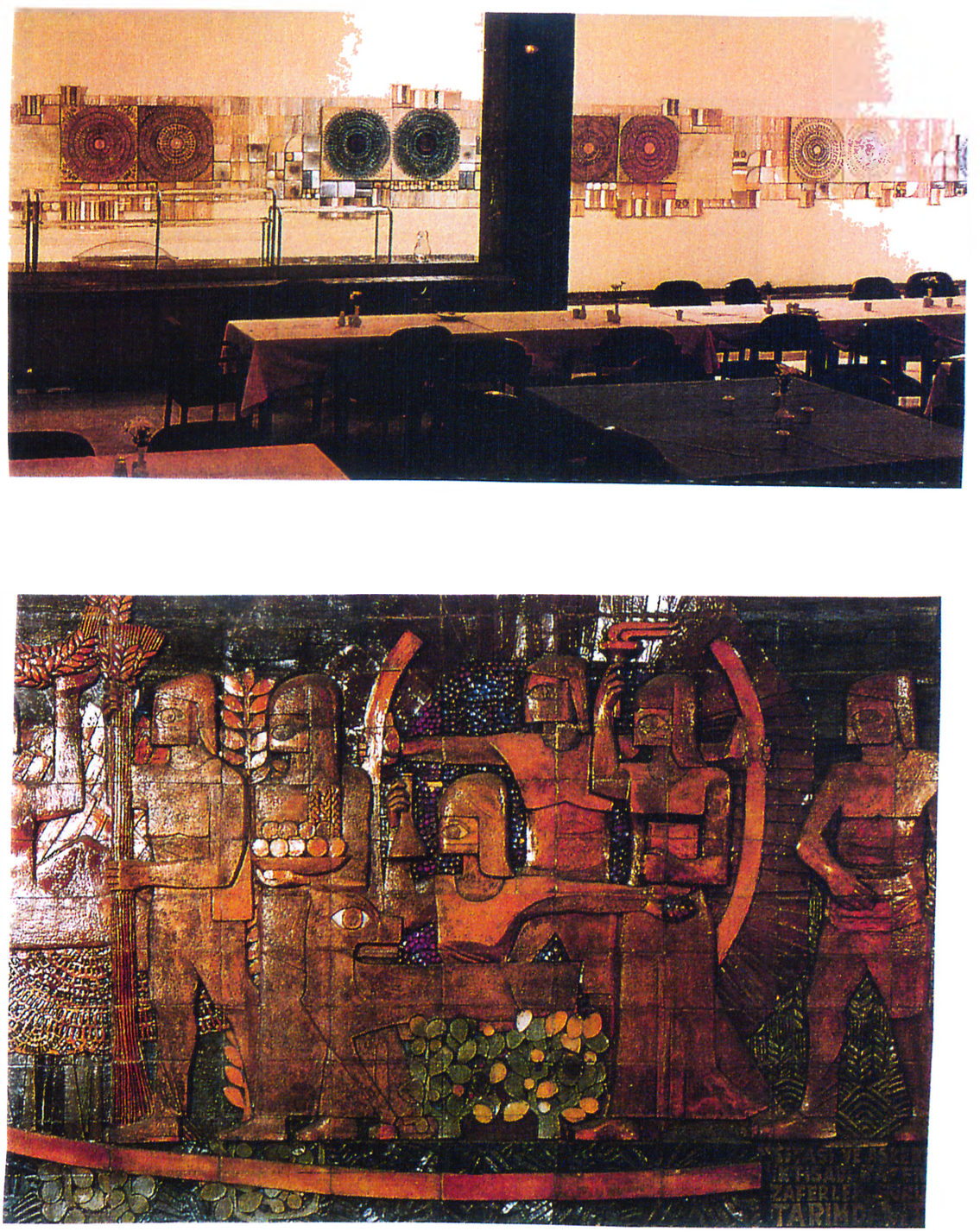


Figure B.22. Examples for the Works of Attila Galatalı.

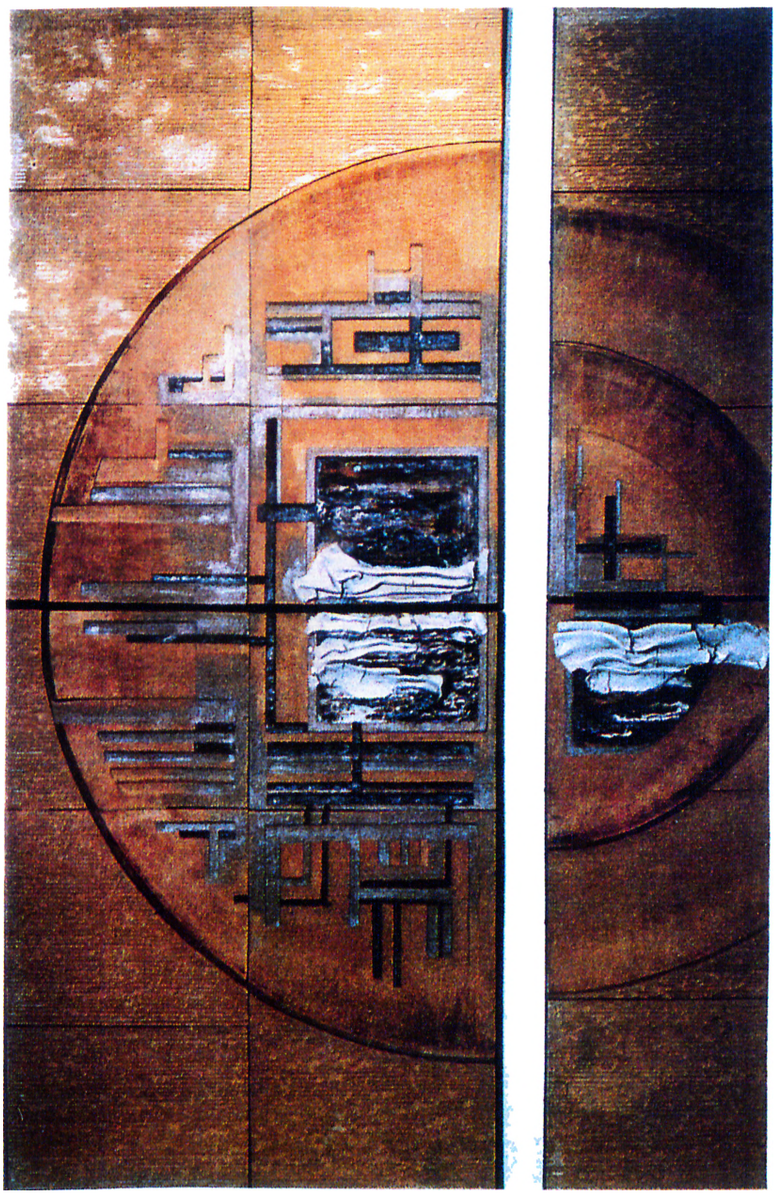


Figure B.23. An Example for the Works of Hamiye Çolakoğlu

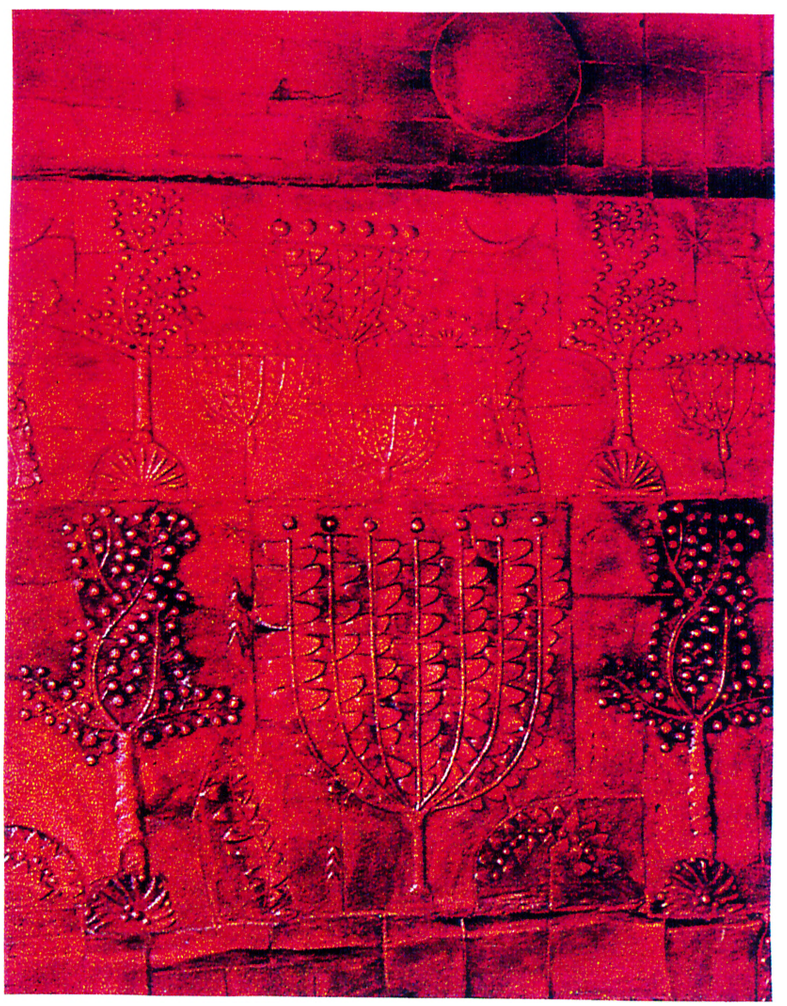


Figure B.24. Examples for the Works of Beril Anılanmert

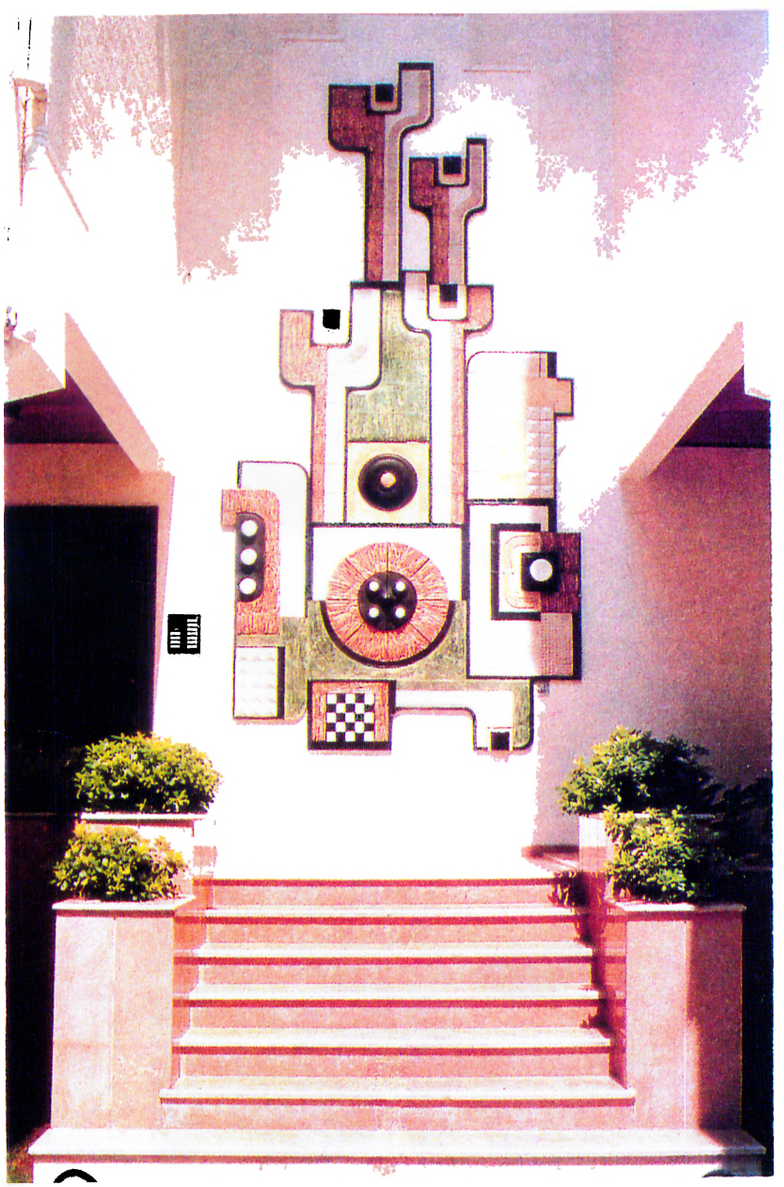


Figure B.25. An Example for the Works of İlgi Adalan.

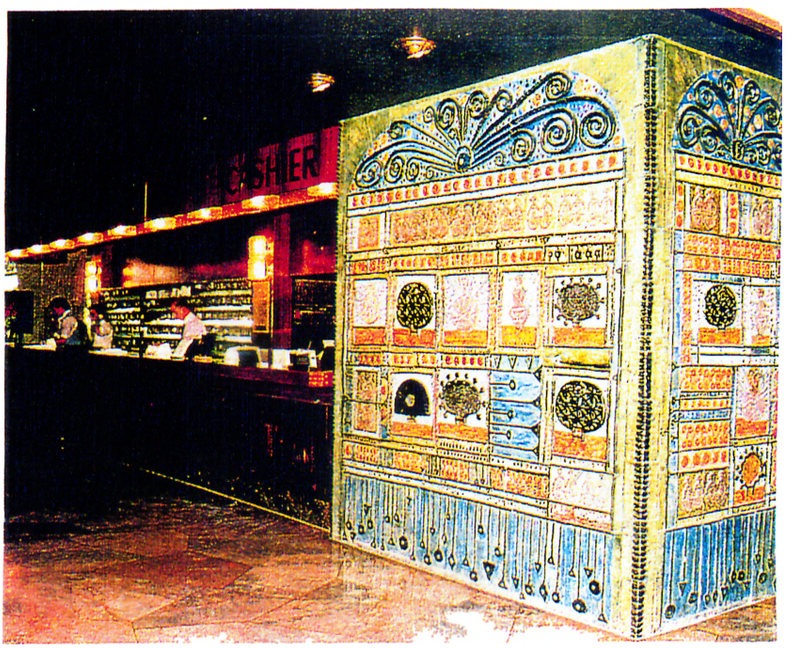


Figure B.26. Examples for the Works of Jale Yılmabaşar

Figure B.27. Examples for Ceramic Tiles Used in Entryways

Figure B.28. Examples for Ceramic Tiles Used in Hallways

Figure B.29. Examples for Ceramic Tiles Used in Staircases

Figure B.30. Examples for Ceramic Tiles Used in Living Rooms

Figure B.31. An Example for Ceramic Tiles Used in Dining Rooms

Figure B.32. Examples for Ceramic Tiles Used in Kitchens

Figure B.33. Examples for Ceramic Tiles Used in Bathrooms

Figure B.34. An Example for Ceramic Tiles Used in Bedrooms

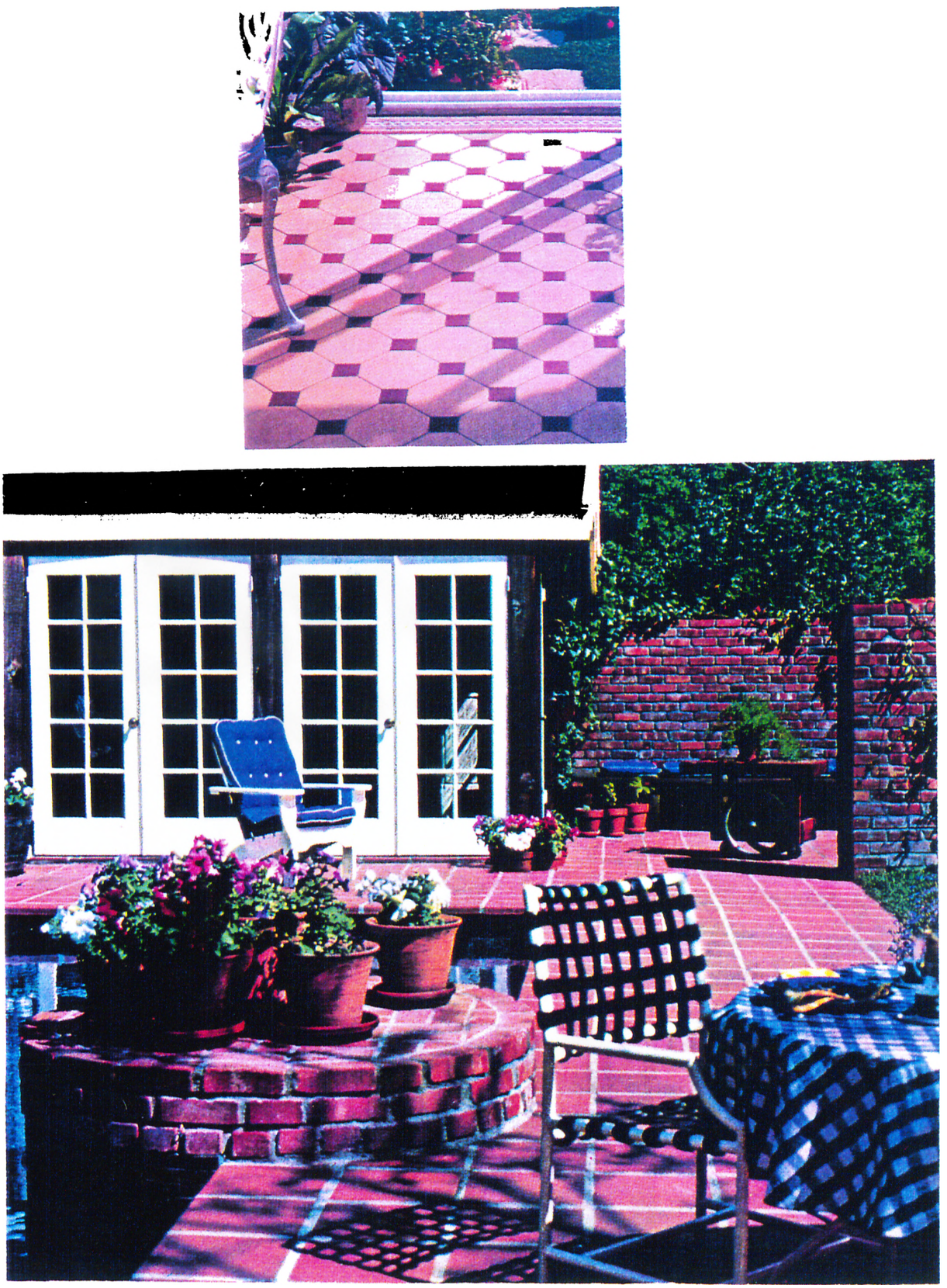


Figure B.35. Examples for Ceramic Tiles Used in Patios

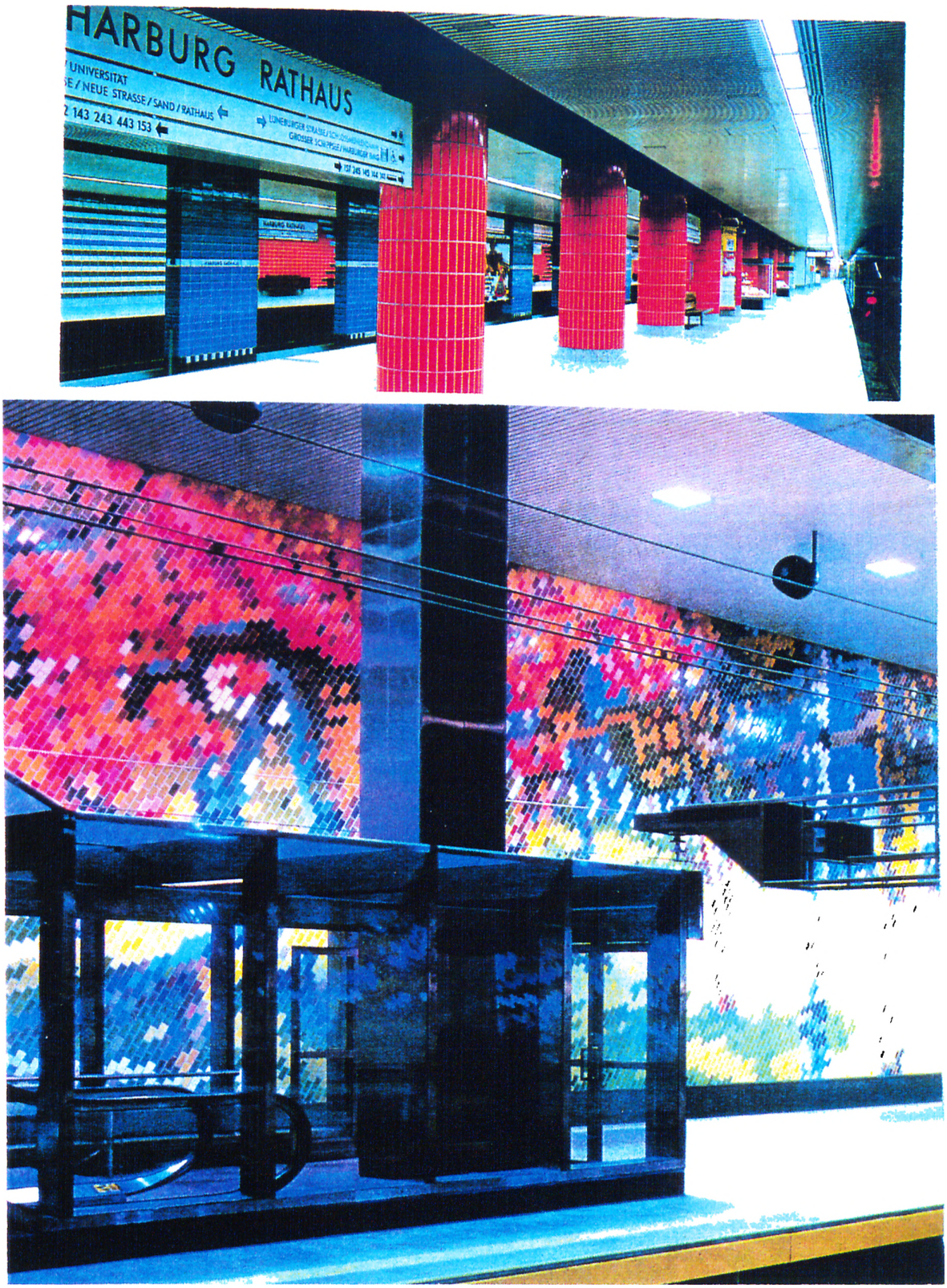


Figure B.36. Examples for Ceramic Tiles Used in Subways and Stations

Figure B.37. Examples for Ceramic Tiles Used in Restaurants and Bars

Figure B.38. An Example for Ceramic Tiles Used in Hotels

Figure B.39. Examples for Ceramic Tiles Used in Hospitals and Medical Centers.

Figure B.40. Examples for Ceramic Tiles Used in Airports

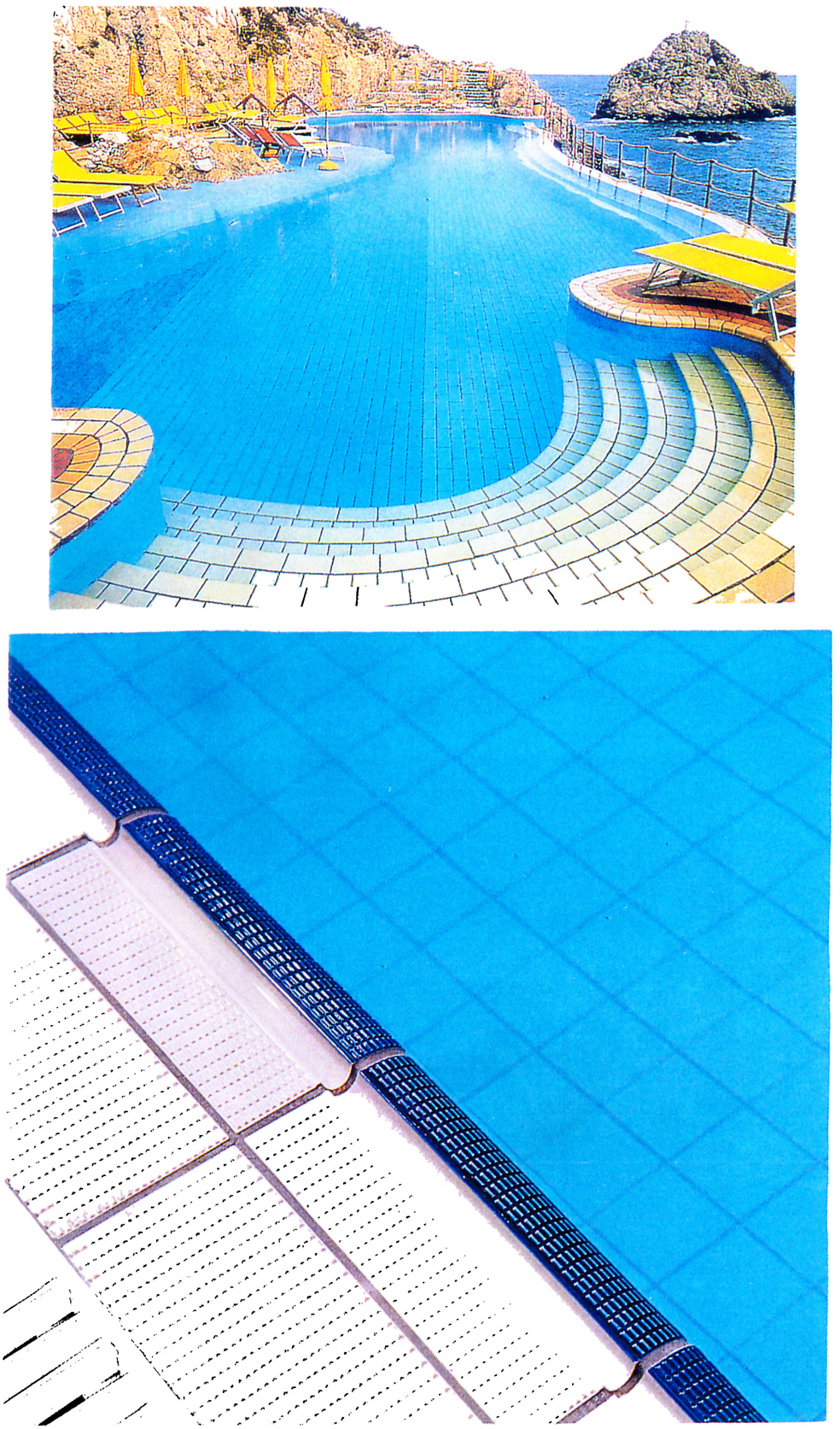


Figure B.41. Examples for Ceramic Tiles Used in Swimming Pools

Figure B.42. Examples for Ceramic Tiles Used in Offices.

Figure B.43. An Example for Ceramic Tiles Used in Parks and Walkways

Figure B.44. Examples for Ceramic Tiles Used in Shopping Malls

Figure B.45. Examples for Ceramic Tiles Used in Industrial Buildings